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ABSTRACT

INFORMATION IS PRESENTED REGARDING COSTS OF INEXPENSIVE TYPES OF CLEAR-SPAN STRUCTURES THAT ENCLOSE AREAS USED FOR RECREATIONAL AND ATHLETIC ACTIVITIES. THE COSTS OF SEVEN DISTINCT TYPES OF READILY AVAILABLE STRUCTURES, AND SEVERAL VARIATIONS OF TWO OF THEM, ARE ANALYZED AND COMPARED. THESE COSTS, INCLUDING THE CHARGES FOR FINANCING, OPERATION, AND MAINTENANCE AS WELL AS THE INITIAL COSTS, ARE COMPARED FOR THREE ALTERNATIVE ANNUAL TERMS OF USE OVER PERIODS OF 5, 10, AND 20 YEARS. DETAILED COST CALCULATIONS FOR EACH OF TWELVE VARIATIONS OF APPROPRIATE STRUCTURES ARE PRESENTED, SUMMARIZED IN BOTH TABULAR AND GRAPH FORM. RECOMMENDATIONS ARE INCLUDED AS TO THE ESSENTIAL FEATURES OF THE "IDEAL" STRUCTURE FOR USES OF THIS KIND. (FS)

AN INVESTIGATION OF COSTS OF INEXPENSIVE ENCLOSURES FOR RECREATIONAL AREAS

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A B S T R A C T

Educational institutions are finding an increasing need for inexpensive types of clear-span structure to enclose, often on a temporary basis, areas used for recreational and athletic activities. Structures being used for such purposes include the air-supported "bubbles", geodesic domes, prefabricated steel buildings and other conventional as well as experimental types.

In view of the growing interest in such applications, and to obtain, for the benefit of all interested parties, reliable data as to the relative costs of alternative enclosure systems over various periods of time, the Educational Facilities Laboratories has sponsored this study. The costs of seven distinct types of readily available structures, and several variations of two of these, have been analyzed and compared. These costs include not only the initial costs, but also the charges for financing, operation and maintenance, and they are compared for three alternative annual terms of use over periods of 5, 10 and 20 years.

Detailed cost calculations for each of twelve variations of appropriate structures are presented, and these are summarized in both tabular and graph form. It is found that, of the various types analyzed, the air-supported structure, if dismantled and removed each year during summer months, costs the least over a 5-year period and appears to have a small overall cost advantage for the 10-year period. For year-round use in place, however, it is the most expensive type, even for the 5-year period, due to the necessity of providing summer air conditioning. The other (rigid) structures can be sufficiently insulated and ventilated, without air conditioning, to provide reasonable summer comfort at much lower overall costs. If the 20-year period of use is a possibility, the air-supported structure, even if removed during the summer months, will likely prove more expensive than other types, because of periodic replacement costs.

Conclusions resulting from the study lead to recommendations as to the essential features of the "ideal" structure for uses of this kind.

INVESTIGATION OF COSTS OF INEXPENSIVE ENCLOSURES FOR RECREATIONAL AREAS

Introduction

There has developed, in recent years, an increasing need among educational institutions, both public and private, for inexpensive wide-span structures to enclose large areas used for recreational and athletic activities. In many cases such needs may be temporary, pending the availability of funds for a permanent gymnasium or field house. In other situations they result from the conviction that although a conventional field house would be an unwarranted luxury, the provision of some kind of low-cost all-weather enclosure can readily be justified.

Several types of structure, in a wide range of sizes, have been used to provide such enclosures for all kinds of activities. One type commonly used, because of its low initial cost and other attractive features, has been the air-supported, or "bubble" structure. Others have been variations of the geodesic dome structure and prefabricated metal buildings. And because the market for structures appropriate for this rather unique purpose is undoubtedly expanding, a number of other types, all aimed at minimal cost, has been designed, and many of these have been built experimentally.

Obviously, low cost is a prime concern with all such structures, as the original intent, in most cases where they are used, is that they are to serve only as a temporary expedient. But it is a well known fact that such "temporary" structures, especially if they prove to be satisfactory and useful, often continue to serve much longer than intended, becoming quite permanent assets. In view of the widespread interest in, and need for, structures of this type, and for information regarding their relative costs, the Educational Facilities Laboratories has undertaken to determine how some of the more commonly used types actually do compare in cost, not only initially but over various periods of time.

Accordingly, an analysis has been made of the costs of a number of readily available "package" types of low-cost long-span structures suitable for the purposes indicated. These costs include not only the cost of the structure itself, but costs of mechanical equipment and charges for financing, operation and maintenance over periods of 5, 10 and 20 years. Furthermore, to provide data pertinent to various operational programs, for each of these three periods, the costs of three alternative "terms" of use have been investigated:

Term A: Nine months' daytime operation, September 1 to June 1 (or 39 weeks), 8 AM to 5 PM, five days per week;

Term B: Nine months' day and night operation (39 weeks), 8 AM to 10 PM, seven days per week, and

Term C: Year-round day and night operation, 8 AM to 10 PM, seven days per week.

Seven different types of structure have been included in the study: an air-supported ("bubble") structure, a frameless corrugated steel arch structure, two kinds of rigid frame metal building, a geodesic dome structure, a plywood building and a long-span trussed steel arch building. In the case of the air-supported structure, both a 5-year and 7-year useful life expectancy were investigated, and for each of these, for the 12-months' term of use, alternate costs of dismantling or air conditioning during the summer months were computed. Three variations of the frameless steel arch building were also investigated, one with no insulation, one insulated, and one with both insulation and skylight panels. Thus, all told, the study has involved twelve different variations of structure, as listed on the following page, each being "priced" for nine different terms of use.

Though every effort has been made to be as accurate as available information allows, it should be understood that the results of this study are to be considered tentative and approximate, rather than conclusive and precise. For some of the structures, "hard" cost data has not yet been obtained, making it necessary to rely on educated estimates to some degree. Significant errors in such estimates could of course invalidate certain comparisons.

It should be recognized, too, that this study is by no means all-inclusive in respect to structure types. It represents merely a sampling of possible solutions, and deals only with certain arbitrarily selected versions of these structures. An analysis of the results suggests that probably none of the rigid type structures as described

fully represents the most economical version for periods of use exceeding 7 or 8 years. But it indicates also, that with certain minor revisions in these structures, their costs over such periods of use could be significantly reduced.

STRUCTURES ANALYZED

No.*	Description (see Appendix A for sketches and data)	Area Sq.Ft.
1a	Air-Supported Structure, 5-year life dismantled & stored during summers	15,000
1b	Air-Supported Structure, 5-year life air conditioned in summer	15,000
1c	Air-Supported Structure, 7-year life dismantled & stored during summers	15,000
1d	Air-Supported Structure, 7-year life air conditioned in summer	15,000
2a	Frameless Corrugated Steel Arch, uninsulated (Wonder Building)	15,000
2b	Frameless Corrugated Steel Arch, insulated (Wonder Building)	15,000
2c	Frameless Corrugated Steel Arch, insulated, with skylights (Wonder Building)	15,000
3	Rigid Frame Metal Building, insulated (Butler)	14,400
4	Plywood Building with folded plate roof, insulated	14,000
5	Geodesic Dome Structure (Charter Industries) aluminum frame, suspended fabric	10,200
6	Trussed Steel Arch Building, sheet steel covering, insulated (Butler "Triodetic")	30,000
7	Steel Rigid Frame, metal roof, insulated; lightweight concrete block walls (Varco-Pruden)	37,330

* Identification number used in text and on graphs and tables.

Parameters and Criteria

To make the cost comparisons as objective and meaningful as possible, the following general parameters and criteria were established:

1. The structure is to be located in, and priced for, the New York metropolitan area.

2. The enclosed space is to be used for general recreational and playground activities not requiring special lighting or other facilities.

3. The structure is to be erected directly on the ground, with no flooring and no interior finish or furnishings, on a site prepared by others.

4. The structure is to be capable of carrying a 30-pound snow load and withstanding a wind load of 20 pounds per square foot.

5. Interior temperatures are to be maintained as follows:

   During the 9-months' use periods (Terms A and B), a minimum of 60°F during use, and 45°F during off hours;

   During summer months (June 1 to September 1), a maximum of 3°F above outdoor ambient temperature.

   Appropriate allowance is to be made for solar heat gain through translucent shell materials, and from two to four air changes per hour are to be provided by the heating system.

6. Lighting is to be provided at the rate of 3 watts per square foot of covered ground area, producing approximately 30 to 45 foot-candles on the ground, depending on the type and location of lighting fixtures.

7. Building costs are to include all necessary foundation work, complete erection, all mechanical equipment necessary for heating, lighting, ventilation and air conditioning (if required), but no interior finish, furnishings or other equipment.

   For purposes of comparison, costs are to be calculated for three alternative annual terms of usage, Terms A, B and C as previously defined.

8. Overall costs, consisting of initial building costs, operating and maintenance costs and financing charges, are to be computed for periods of 5, 10 and 20 years, with amortization of capital costs being based on a 7% interest rate.

Approach to Cost Analysis

There are several prerequisites for comparing the costs of two or more structures, the most obvious being the initial cost of each structure. If the comparison is to be valid, it's essential also that the conditions governing their use be the same in all cases.

A true cost comparison represents total anticipated costs during the expected period of use, however, rather than simply first costs alone. Thus the costs compared should include not only the initial costs of the structure in place and ready for use, but also the costs of operating and maintaining the structure during its useful life, plus the cost of amortizing the purchase price.

Consideration must be given also to the probable useful lives of the structures being compared. If they are essentially the same, this factor has no significance, but if

the life expectancy of some of the structures is much shorter than that of others, proper allowance must be made for this fact. It seems logical that when the life expectancy of a structure exceeds the length of the period for which costs are being compared, a reasonable salvage value, or remaining worth value, should be credited to the cost of that structure when determining its overall cost for the period. If, on the other hand, the useful life of a structure is known to be less than the length of the period for which costs are being calculated, the expense of replacement during the period must be taken into account.

To determine the comparative costs, over a period of time, of the type of structure being considered, the following procedure is considered proper, and has been used in this study:

1. Establish the location where the structures are to be built, so that all costs will be based on prices in that area.
2. Determine the initial cost of the building shell erected in place, without mechanical equipment.
3. Establish the intended annual term of use; what hours of the day, how many days per week and what months during the year it is to be used.
4. Establish the interior temperatures to be maintained during both the hours of use and during off hours.
5. Determine design temperature and degree days, and calculate the heat loss during winter months.
6. Calculate ventilation or air conditioning requirements during summer months.
7. Determine the level of lighting to be provided.
8. Estimate probable initial costs of heating, ventilation (or cooling) and lighting equipment required.
9. Calculate the annual operating costs, - the costs of heating, ventilation, cooling (if required) and lighting.
10. Estimate probable maintenance costs.
11. Determine the gross cost for the period of years under consideration by adding:
    a) Initial cost of building shell and mechanical equipment, amortized at the anticipated interest rate over the period,
    b) Annual operating costs, multiplied by the number of years, and
    c) Estimated maintenance costs during the period.
12. Determine the net cost for the period by subtracting from the gross cost the estimated salvage value (if any) at the end of the period.

Explanation of Cost Calculations

It should be emphasized that the purpose of this study has been to determine relative, rather than exact costs. This, we believe, has been accomplished, and the findings have led to certain conclusions which are stated later. The study has also, however, raised certain questions and doubts which may warrant further investigation. To facilitate understanding and interpreting the results, the sources of information and some of the assumptions made should be explained, and certain seeming inconsistencies in the data available should also be noted.

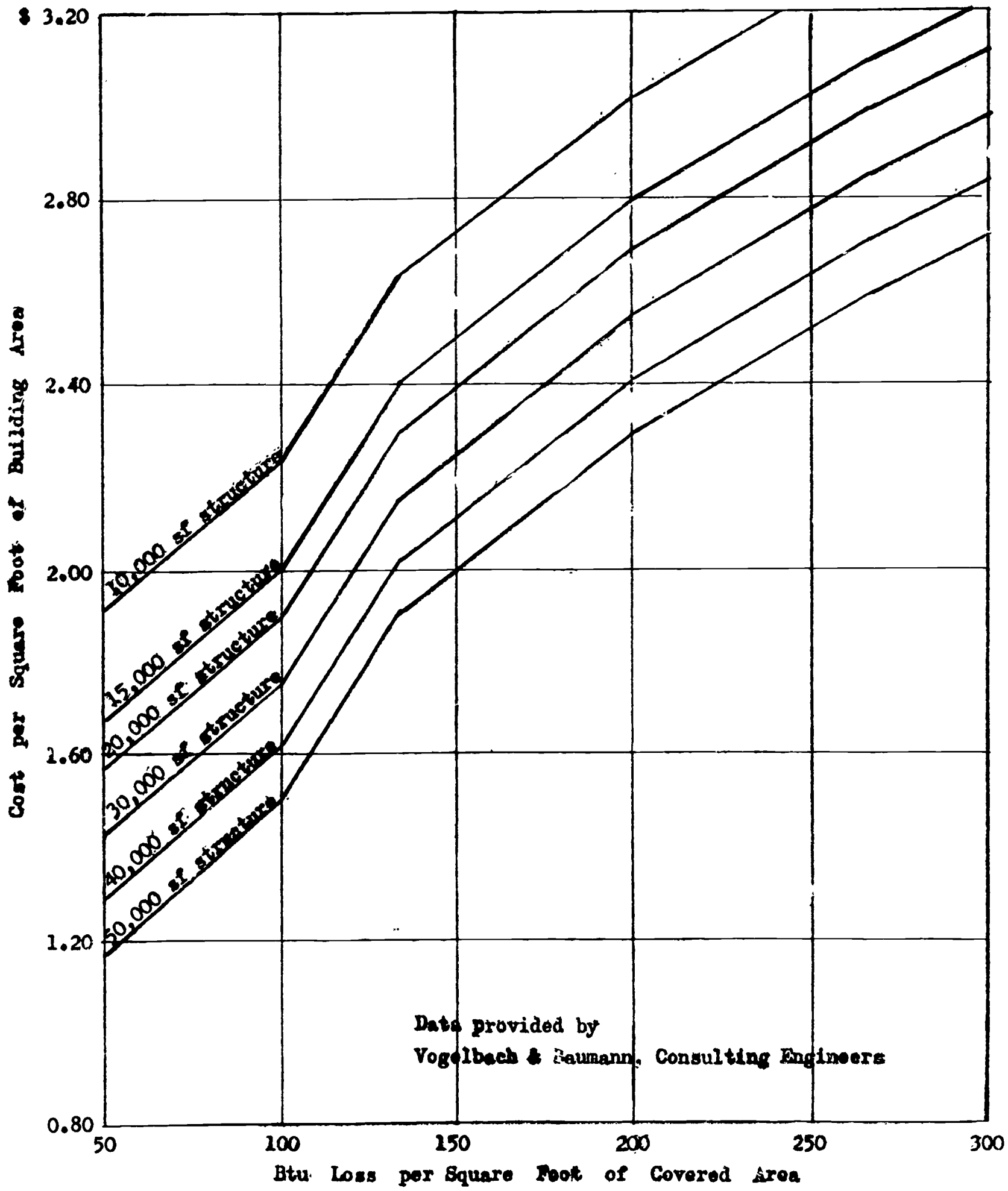
Building Shell Costs: The initial costs used for the various structures are believed to be reasonably correct (within 10%), but are not claimed to be precise. Within the limits of time and budget available more accurate figures could not be obtained. For the air-supported structures, these costs represent an average of prices listed and quoted by several different manufacturers. For the plywood building, the geodesic dome structure and the two Butler buildings, itemized prices ("± 10%") were quoted by representatives of the companies supplying such buildings, and prices for the Varco-Pruden rigid frame structure represent those actually paid for a building of the same type and size recently erected in the New York area. For the several versions of the Wonder Building, however, only a "package price", excluding costs of foundations, insulation, skylights and erection, was provided by the manufacturer's representative. These prices the author supplemented with his own educated estimate of the costs of such items. Detailed breakdowns of the various cost estimates will be found in the Appendix, following the cost calculations and summaries. If more accurate information is desired, all building costs, and especially those of the Wonder Buildings, should be verified.

Costs of Mechanical Equipment and Operation: Except for the air-supported structures, the installation and operating costs of heating, ventilating, air conditioning and lighting equipment were calculated by Vogelbach & Baumann, consulting engineers, who collaborated in the study. The costs of heating equipment and its installation have generally been found to vary, in the rigid structures, from $1.55 to $2.86 per square foot of covered area, depending on heat loss and building size, as shown on the graph of Figure A. The cost of lighting installation, except in the air-supported structures, was assumed to be $1.50 per square foot. Thus, in all of the rigid structures, the initial total cost of mechanical equipment ranges from $3.05 to $4.36 per square foot of covered area.

FIGURE A

COST OF INSTALLED HEATING EQUIPMENT, PER SQUARE FOOT OF BUILDING AREA

Direct-Fired Warm Air Heater Units with Blowers



The cost of supposedly similar equipment for the air-supported structures was obtained from two sources: price lists published by Air-Tech Industries and conversations with several manufacturer's representatives. These costs are seen to be much lower than the costs used for equipment in the rigid structures as noted above, - a seeming inconsistency that warrants further investigation. The reasons for such a large difference in these costs are not wholly clear, and of course they materially affect the overall comparative costs.

Heating costs for Terms A and B have been based on the use of No. 4 fuel oil at 10.5 cents per gallon Lighting was assumed to require 3 watts per square foot of ground area in all cases, but the number of hours when lighting is required is, of course, not the same in all structures. The cost of electric power has been assumed to be 2 cents per kilowatt-hour.

Operating costs for Term C (year-round) have been calculated by adding the costs of lighting and ventilating or air conditioning for the three summer months to the lighting and heating costs for Term B (9 months). This procedure, we recognize, results in a figure which is not entirely accurate, since it neglects the fact that summer ventilation or cooling may be required on some days before June 1 and after September 1. However, since the operating costs for these few additional days would be relatively quite small, their omission does not significantly affect the overall comparison.

Replacement Costs for Air-Supported Structures: To investigate the overall cost effects, two different terms, 5 and 7 years, were used for the life expectancy of the air-supported structures. It is believed that, for the usual type of such structure, 5 years of useful life is the more common experience, but that some of the better types may be expected to serve 7 years before replacement.

In both cases, the overall costs calculated for service periods longer than the assumed life expectancy of the structure necessarily include estimated replacement costs during the period. In all of these structures it was assumed that the mechanical equipment originally installed in the first structure would serve through the full 20-year term, requiring no replacement but a certain amount of repair and reconditioning. It was also assumed that the cost of replacing the "skin" would be somewhat less than the initial shell cost, allowing for the re-use of ground anchors and personnel doors. The net replacement costs thus calculated for each of these structures are noted on the cost summary sheets included in the Appendix. Whether or not these costs are

entirely realistic and valid has not been verified.

As explained under "Salvage Values", these replacement costs should not be confused with the estimated salvage values, for the reasons there stated.

Maintenance Costs: The costs tabulated under this heading in the calculations (see Appendix) are not intended to include all maintenance charges, but only those which are thought to be unique requirements for the structure in question. For example, blower operation costs for the air-supported structures have been assumed to be equivalent to the costs of operating the blower for warm air circulation in the rigid structures, and since such costs are relatively insignificant in all cases, they have been disregarded. The same applies to normal equipment maintenance and repair charges, which are assumed to be essentially the same in all of the structures. In effect, then, the only maintenance charges that have been included are: 1) the costs of painting exterior metal and wood surfaces, and 2) for air-supported structures No. 1a and 1c, the annual costs of dismantling the structure in the spring and re-erecting it in the fall.

Salvage Values: The salvage values listed in the calculations for both the building shell and the mechanical equipment are admittedly and necessarily estimates, based on the nature of the structure, but are believed to be reasonably fair allowances. They are intended to represent the remaining salable value at the end of the period indicated if the materials are removed from the site for use elsewhere. The replacement costs for the air-supported structures, referred to above, are costs based on the assumption of continued use in the same location, and hence are not determined by simply subtracting the salvage value from the initial cost.

Summary of Findings

The calculated comparative costs resulting from this study are shown in tabular form on Table 1, and in graphic form in Figures B, C and D on the following pages. It should be pointed out, however, that, of the twelve variations of structure analyzed, only seven are directly comparable, for these reasons:

- the two air-supported structures, Nos. 1a and 1c, because they are dismantled and removed during the summer, do not provide full year-round coverage and enclosure as do all of the other structures;

- the geodesic dome structure is relatively small, having only about two-thirds the coverage area of most of the other structures and therefore is penalized costwise to some extent. Generally, unit costs tend to vary somewhat, in inverse proportion to size, and this structure would probably be a little less expensive per square foot if it were half again as large.
- structures Nos. 6 and 7 have at least double the coverage of any of the others, and therefore likely have some advantage in unit costs, for the reasons just stated. A trussed arch structure of lesser span would be unfeasible, but the No. 7 type is readily available in smaller sizes, probably at a little higher unit cost.

Nevertheless the study has produced useful and helpful information, from which certain conclusions regarding the relative costs of the various types of building may safely be drawn. Chief among these appear to be the following:

1. In respect to the 9-months' terms of use (Terms A and B):

   a. Over a period of 5 years, the air-supported structures are obviously the most economical. It must be recognized, however, that on some warm days in the spring and fall the "greenhouse effect" of solar heat gain in these structures will likely result in some uncomfortably high interior temperatures.

   b. Over a period of 10 years, the 7-year-life air-supported structure has the lowest overall cost of the structures analyzed, and the 5-year-life structure also has a slight cost advantage. It is not unlikely, however, that with certain design modifications in some of the other structures, increasing the insulation and perhaps decreasing the amount of translucent area, the relative economies might change.

   c. Over the 20-year period the air-supported structures appear to offer no cost advantages over the other types of structure. Undoubtedly several of the other types, if better insulated, would have much lower costs by comparison.

   d. Whether the operation is 9 hours a day (Term A) or 14 hours a day (Term B) makes little difference in the relative costs of the various structures.

2. In respect to year-round use (Term C):

   a. The air-supported structures are the most expensive if left in place during the summer, due to the necessity of air conditioning.

b. If it is acceptable to have the site uncovered during the summer months, removing and re-installing the structure each year, the air-supported structures offer cost advantages for the 5- and 10-year periods. Over the 20-year period, the 7-year-life "bubble", if used in the same way, may also be competitive costwise, but other types of structures with good insulating values will likely prove to have lower overall costs.

c. Year-round operating costs for the other (rigid) structures, in which summer air conditioning is not a requirement, depend on either the insulating value of the shell or the amount of solar heat gain and daylighting provided. In general, these costs are found to average about as follows:

Over the 5-year period - 25 to 40% Over the 10-year period - 50 to 80% Over the 20-year period - 100 to 160%	of the initial cost of building and equipment

3. In general:

a. The advisability of using skylight panels in otherwise opaque roofs is debatable, and depends on the intended use. For Term A (9-hour daytime use), ample skylighting undoubtedly reduces operating costs because of the natural lighting and solar heat gain provided, but for 9-months' day-and-night use (Term B), the heat loss through skylights at night is likely to exceed any daytime gain. In summer use the extra heat gain from skylights will likely be a liability, rather than an asset, requiring more ventilation to maintain comfort, but they still offer the advantage of daylighting.

The use intended for the building is also an important determinant. For general playground types of activity, the daylighting provided by skylights can be quite desirable. However, for tennis or other sports necessitating the visual tracking of a ball in mid-air, they usually are a distracting handicap.

b. An ideal structure for year-round use in parts of the country having 5000 or more winter degree days (e.g. the New York area)

would be one having a low initial cost, high insulating value and large removable wall sections at ground level, along with ample high vent areas and adequate ventilating equipment, to provide reasonable summer comfort without air conditioning. In the warmer parts of the country, where summer comfort necessitates air conditioning in any case, there would be no removable wall sections and less ventilating capacity, but even higher insulating values would be provided in the building shell.

SUMMARY OF RELATIVE COSTS

TABLE 1

In each column are shown, in order of increasing cost, the Key Numbers of the various structures and, after parenthesis, the relative cost of each.

TERM A			TERM B			TERM C		
Build'g Cost* & (Ratio)	Op.& Mtce Cost & (Ratio)	Total Cost & (Ratio)	Build'g Cost* & (Ratio)	Op.& Mtce Cost & (Ratio)	Total Cost & (Ratio)	Build'g Cost* & (Ratio)	Op.& Mtce Cost & (Ratio)	Total Cost & (Ratio)
5 - YEAR PERIOD								
1c, 1d (1.00	2c (1.00	1c, 1d (1.00	1c, 1d (1.00	7 (1.00	1c, 1d (1.00	1c (1.00	2c (1.00	1c (1.00
1a, 1b (1.12	5 (1.05	1a, 1b (1.07		2c (1.02		1a (1.12	5 (1.05	1a (1.06
7 (1.59	7 (1.06	7 (1.45		5 (1.10	1a, 1b (1.06	7 (1.58	4 (1.14	7 (1.36
6 (1.68	1a, 1b, 1c, 1d (1.07	6 (1.59		1a, 1b, 1c, 1d (1.12	7 (1.36	6 (1.72	7 (1.20	6 (1.44
2b (1.76		2b (1.65			6 (1.50	2b (1.79	6 (1.24	2c (1.48
2c (1.88	4 (1.10	2c (1.69			2b (1.57	2c (1.92	1a, 1c (1.26	2b (1.50
3 (1.89	2b (1.19	3 (1.77		4 (1.14	2c (1.58	3 (1.94	2b	3 (1.60
4 (1.92	6 (1.26	4 (1.80		6 (1.20	3 (1.68	4 (1.97	3 (1.34	4 (1.61
2a (1.94	3 (1.31	2a (1.98		2b (1.21	4 (1.71	2a (1.98	1b, 1d (1.44	5 (1.75
5 (2.29	2a (2.04	5 (2.05		3 (1.80	2a (1.88	5 (2.34		2a (1.79
			5 (2.29	2a (1.84	5 (1.89	1d (2.38		1d (1.87
			same as Term A			1b (2.49	2a (1.77	1b (1.92
10 - YEAR PERIOD								
1c, 1d (1.00	2c (1.00	1c, 1d (1.00	1c, 1d (1.00	7 (1.00	1c, 1d (1.00	1c (1.00	2c (1.00	1c (1.00
7 (1.03	7 (1.06			2c (1.02		7 (1.07	4 (1.12	1a (1.05
6 (1.11	1a, 1b, 1c, 1d (1.07	1a, 1b (1.06		1a, 1b, 1c, 1d (1.12	1a, 1b (1.06	6 (1.14	7 (1.14	7 (1.11
1a, 1b (1.16		7 (1.15			7 (1.09	1a (1.16	6 (1.49	2c (1.19
2b (1.20	4 (1.10	6 (1.29			6 (1.23	2b (1.23	2b	6 (1.20
3 (1.25	2b (1.19	2b (1.35		5 (1.14	2c (1.29	3 (1.28	1a (1.50	2b (1.25
2c (1.29	6 (1.26	2c (1.36		4 (1.15	2b (1.30	2c (1.32	1c	3 (1.32
2a (1.32	3 (1.31	3 (1.42		6 (1.20	3 (1.37	2a (1.34	3 (1.61	4 (1.34
4 (1.34	5 (1.71	4 (1.49		2b (1.21	4 (1.43	4 (1.51	5 (1.69	5 (1.39
5 (1.52	2a (2.05	2a (1.69		3 (1.30	2a (1.61	5 (1.55	1b, 1d (1.73	2a (1.44
		5 (1.76	5 (1.52	2a (1.83	5 (1.66	1d (2.04		1d (1.65
			same as Term A			1b (2.28	2a (2.15	1b (1.70
20 - YEAR PERIOD								
7 (1.00	7, 2c (1.00	1c, 1d (1.00	7 (1.00	7 (1.00	7 (1.00	7 (1.00	2c (1.00	1c (1.00
6 (1.16		7 (1.03		2c (1.07	1c, 1d (1.02	6 (1.15	4 (1.17	7 (1.01
2b (1.26	1a, 1b, 1c, 1d (1.01	1a, 1b (1.19		1a, 1b, 1c, 1d (1.11	6 (1.08	2b (1.24	7 (1.23	2c (1.07
2c (1.30		6 (1.21			1a, 1b (1.09	2c (1.26	1a (1.29	6 (1.12
3 (1.31	4 (1.03	2c (1.24		4 (1.14	2c (1.20	3 (1.27	1c (1.30	1a (1.14
2a (1.41	2b (1.18	2b (1.27		6 (1.24	2b (1.25	2a (1.37	6 (1.32	2b (1.17
1c, 1d (1.45	6 (1.24	3 (1.33		2b (1.26	3 (1.31	1c (1.41	2b (1.33	3 (1.23
4 (1.53	3 (1.30	4 (1.41		3 (1.35	4 (1.37	4 (1.48	3 (1.42	4 (1.26
5 (1.59	5 (1.[illegible]	2a (1.62		5 (1.77	2a (1.59	5 (1.56	1b, 1d (1.48	2a (1.46
1a, 1b (1.98	2a (1.98	5 (1.72	1a, 1b (1.98	2a (1.88	5 (1.64	1a (1.81		5 (1.47
			same as Term A			1d (2.82	5 (1.64	1d (1.58
						1b (4.04	2a (1.86	1b (1.92

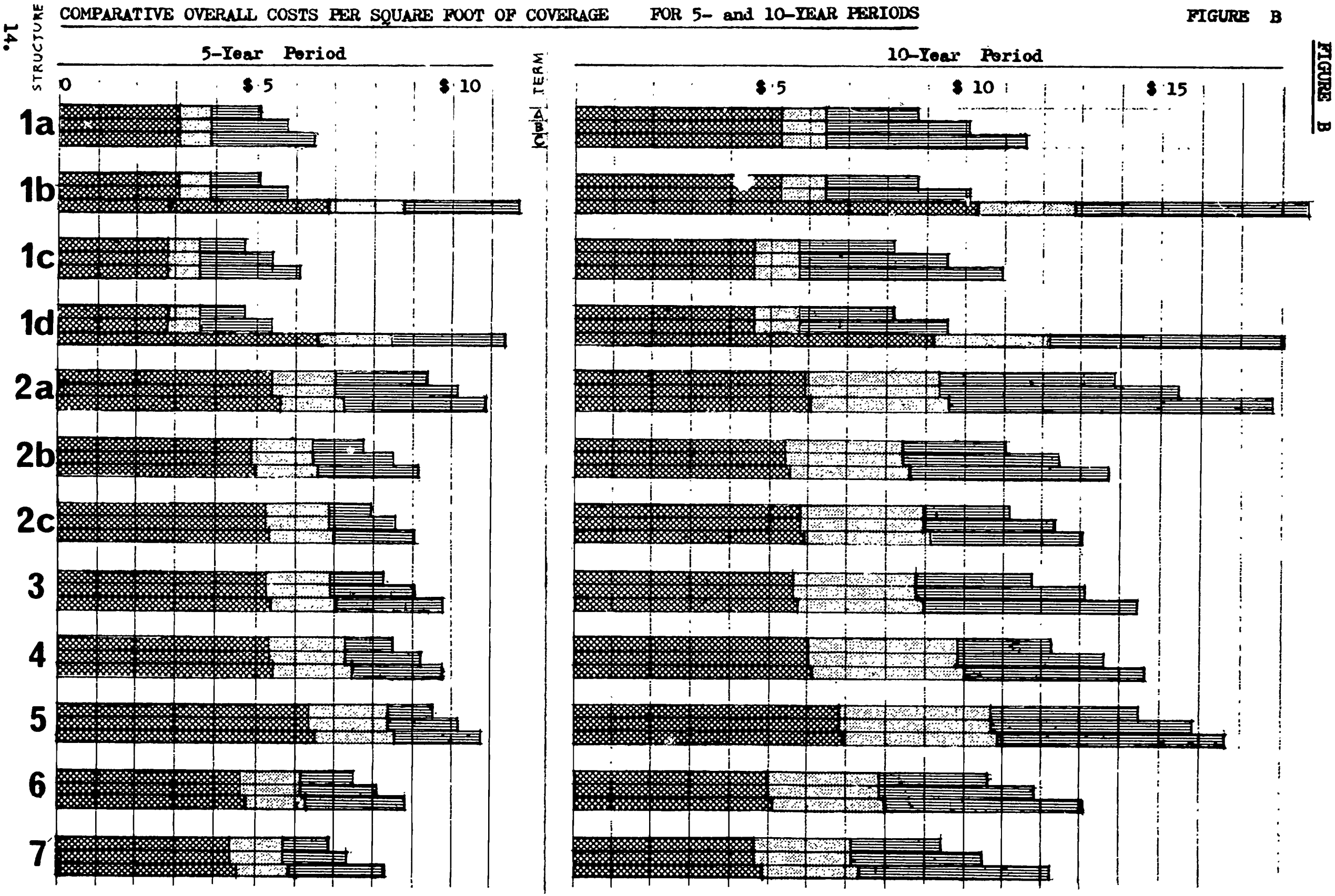
* Actual cost, not including financing, less salvage value at end of period.

KEY: 1a - Air-supported, 5-yr., dismant. summers
1b - " " " air cond. "
1c - " " 7-yr., dismant. summers
1d - " " " air cond. "
2a - Frameless Steel Arch, not insulated
2b - " " " , insulated
2c - Frameless Steel Arch, insul. & skylights
3 - Butler Rigid Frame, insulated
4 - Plywood Building, Folded Plate Roof
5 - Geodesic Dome, suspended fabric cover
6 - Trussed Steel Arch (Triodetic) insulated
7 - Rigid Steel Frame, insul. roof, block walls

14.

COMPARATIVE OVERALL COSTS PER SQUARE FOOT OF COVERAGE FOR 5- and 10-YEAR PERIODS

FIGURE B



KEY: Net Building Cost (orig. cost less salvage) Financing Cost (7% int.) Operating & Maintenance

FIGURE B

COMPARATIVE OVERALL COSTS PER SQUARE FOOT OF COVERAGE FOR 20-YEAR PERIOD

FIGURE C

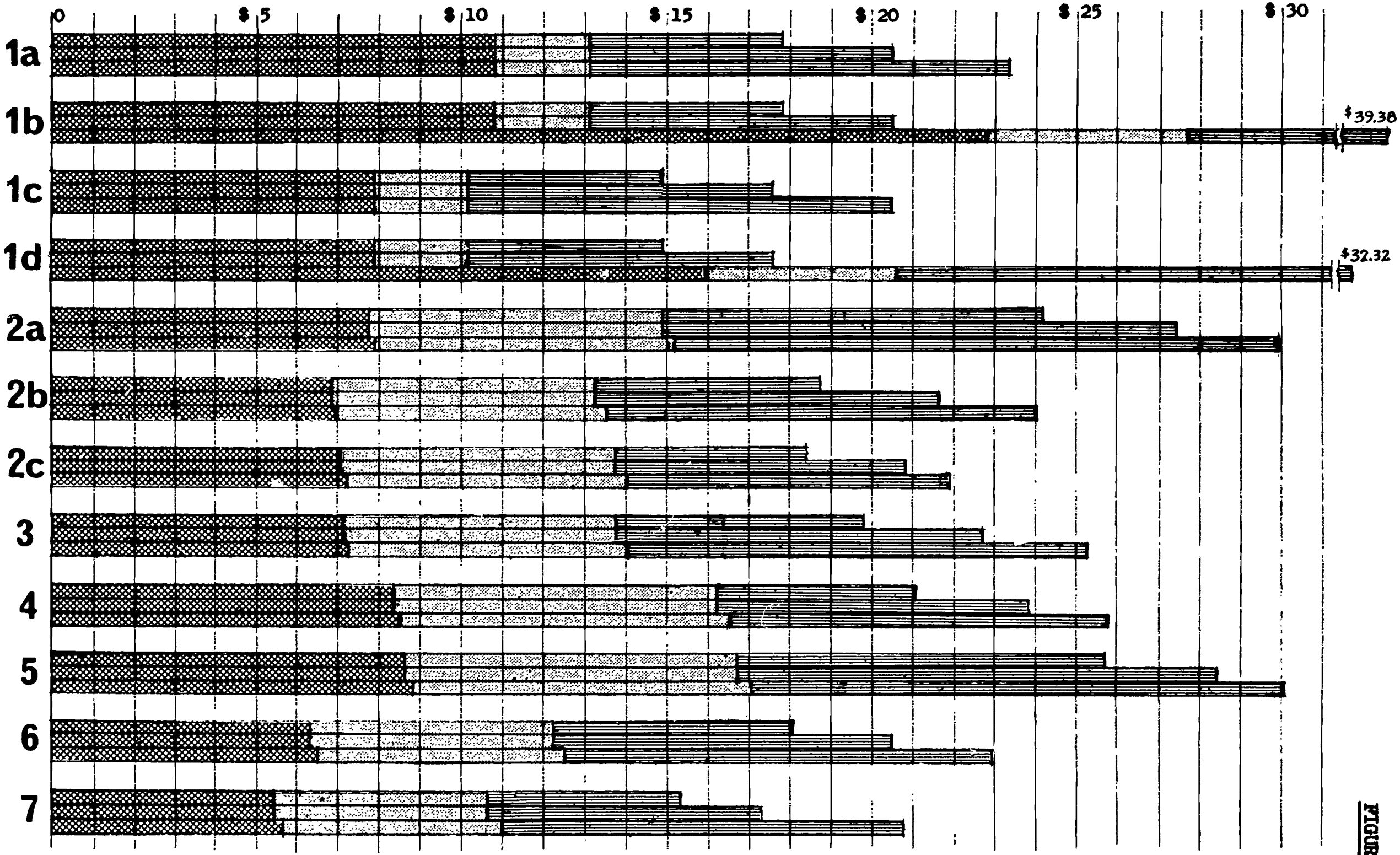
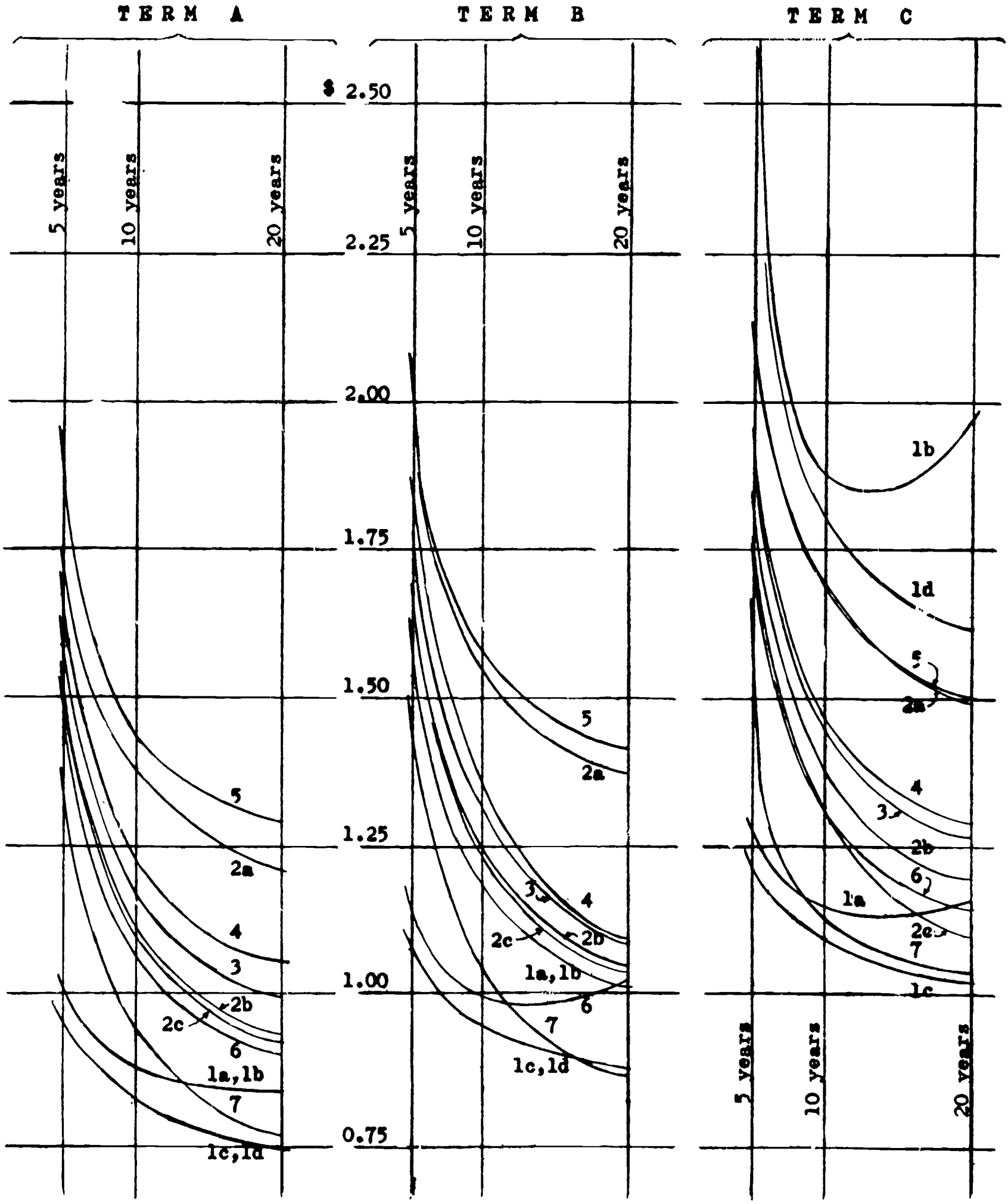


FIGURE C

FIGURE D - COMPARATIVE COSTS PER SQUARE FOOT OF COVERAGE PER YEAR

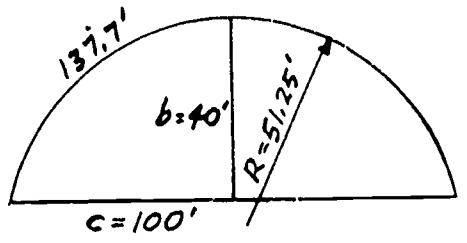


APPENDIX

CALCULATIONS

STRUCTURE No. 1a

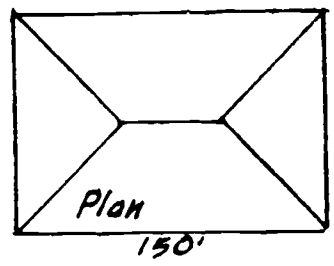
Areas:



$Radius = \frac{4 \times 40^2 + 100^2}{8 \times 40} = 51.25'$

b/c = .40 A° = 154

Arc = .017543 x 51.25 x 154 = 137.7'



Surface area
= approx. 1.01 x 137.7 x 150
= say 20,850 sq. ft.

Heating: Btu Loss - 20,850 sf x 1.20 = 25,020

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

ventilating air (1 cfm/sf) 15,000 x 1.08 = 16,200

	Term A	Terms B & C
41,220 x 60 =	2,473,200	
+ 10% safety	247,320	
Gross Btu Loss per hour	2,720,520	2,720,520
Deduct: Heat gain from lighting: 15,000 sf x 3 x 3.4 x 2/9	34,000 (x 1/2 :	76,500
Estimated solar heat gain: 25 % of gross loss	680,130 (17 %:	463,000
DESIGN BTU LOSS	2,006,390	2,181,020

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 2006.4}{15,000 \text{ s.f.}}$ = $ 0.213 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 2181.0}{15,000 \text{ s.f.}}$ = $ 0.254 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 2 hr/da x 5 da/wk x 39 wks = 390 hrs x 3w/sf = 1.17 kwh @ 2¢ = $ 0.023 /sf/yr
Term B: 7 hr/da x 7 da/wk x 39 wks = 1911 hrs x 3w/sf = 5.73 kwh @ 2¢ = $ 0.115 /sf/yr
Term C: 1911 + 4 hrs x 7 x 13 wks = 2275 hrs x 3w/sf = 6.83 kwh @ 2¢ = $ 0.137 /sf/yr

---

Summer Ventilation or Air Conditioning (Term C only):

Equipment: None

Installation Cost: $ _____ ÷ _____ sq. ft. = $ 0 per sq. ft.

Operating Cost: $\frac{HP \times 0.74565 \times \$0.02 \times \text{hrs.}}{\text{sq.ft.}}$ = $ 0 per sq. ft. per year

---

Assumed Maintenance Costs: Annual dismantling and re-erection of structure - $2000
For each 5-year structure, 5 dismantlings and 4 re-erections
= $9000, or 60¢ per sq.ft.

SUMMARY OF COSTS

STRUCTURE No. 1a

STRUCTURE

Type: Air Supported (Dismantled & Stored during summers)

Area: 15,000 square feet

Materials:

Roof Vinyl-coated Nylon Fabric

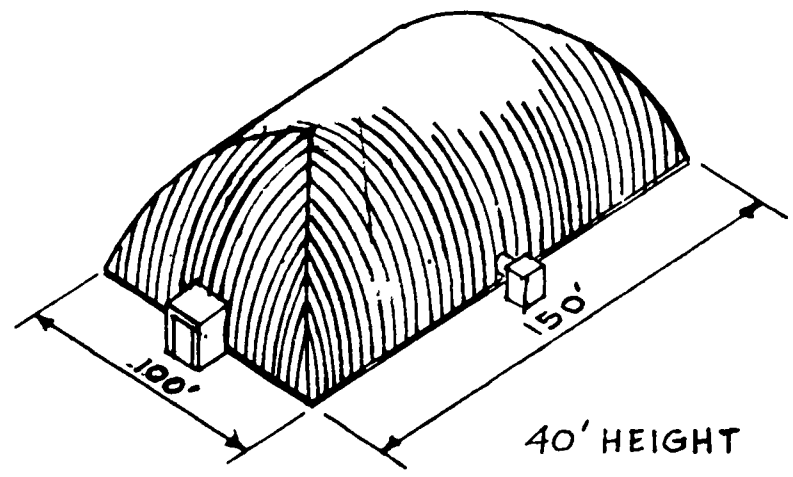
Side walls " " "

End walls " " "

Skylights None

Foundations Ground Anchors

Estimated Life: 5 years



INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 1.90	Roof	1.20	Total: 2,181,200 Btu/hr
Heating & Lighting Eqpmt.	$ 1.60	Skylights	—	Per sq. ft. 145 Btu/hr
Total for Terms A & B	$ 3.50	Side walls, opaque	—	
Ventilating Eqpmt.	$ —	Side walls, transl.	1.20	SUMMER VENTILATION/COOLING
Air Conditioning Eqpmt.	$ —	End walls, opaque	—	None - Structure removed
Total for Term C	$ 3.50	End walls, transl.	1.20	

*see Appendix B

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period (2 struct's.)			20-Year Period (4 struct's)		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over ~~period~~ 5 years	$ 4.27	$ 4.27	$ 4.27	$ 6.71 (1)	$ 6.71	$ 6.71	$ 13.10 (2)	$ 13.10	$ 13.10
Operating: heat & light	1.18	1.85	1.96	2.36	3.70	3.92	4.72	7.40	7.84
ventilating or air cond.	—	—	—	—	—	—	—	—	—
Maintenance	—	—	0.60	—	—	1.20	—	—	2.40
Gross Total Term Costs	5.45	6.12	6.83	9.07	10.41	11.83	17.82	20.50	23.34
Less est. salvage value	0.40	0.40	0.40	0.32	0.32	0.32	—	—	—
NET TOTAL TERM COSTS	$ 5.05	$ 5.72	$ 6.43	$ 8.75	$ 10.09	$ 11.51	$ 17.82	$ 20.50	$ 23.34

1) Credit 10% of shell cost, 80% of mech'l. eqpmt. cost of 1st. struct. on cost of 2nd. Net cost of 2nd struct. = $2.03/s.f.

2) " " " " " , 60% " " " " " 2nd " " " " 3rd. Net cost of 3rd struct. = $2.35 "

" " " " " , 25% " " " " " 3rd " " " " 4th. Net cost of 4th struct. = $2.91 "

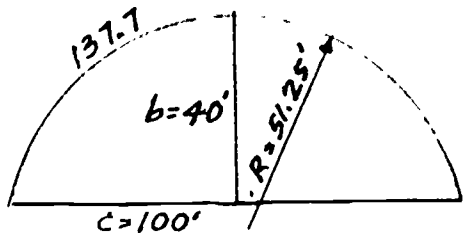
ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	0 %	0 %	0 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 1b

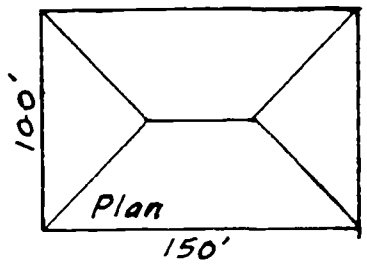
Areas:



Radius = $\frac{4 \times 40^2 + 100^2}{8 \times 40} = 51.25'$

b/c = .40 A° = 154

Arc = .017543 x 51.25 x 154 = 137.7'



Surface area
= approx. 1.01 x 137.7 x 150
= say 20,850 sq. ft.

Heating: Btu Loss - 20,850 sf x 1.20 = 25,020

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

ventilating air (1 cfm/sf) 15,000 x 1.08 = 16,200

	Term A	Terms B & C
41,220 x 60 =	2,473,200	
+ 10% safety	247,320	
Gross Btu Loss per hour	2,720,520	2,720,520
Deduct: Heat gain from lighting: 15,000 sf x 3 x 3.4 x 2/9	34,000 (x 1/2 :	76,500
Estimated solar heat gain: 25 % of gross loss	680,130 (17 %:	463,000
DESIGN BTU LOSS	2,006,390	2,181,020

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 2006.4}{15{,}000 \text{ s.f.}}$ = $ 0.213 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 2181.0}{15{,}000 \text{ s.f.}}$ = $ 0.254 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 2 hr/da x 5 da/wk x 39 wks = 390 hrs x 3w/sf = 1.17 kwh @ 2¢ = $ 0.023/sf/yr
Term B: 7 hr/da x 7 da/wk x 39 wks = 1911 hrs x 3w/sf = 5.73 kwh @ 2¢ = $ 0.115/sf/yr
Term C: 1911 + 4 hrs x 7 x 13 wks = 2275 hrs x 3w/sf = 6.83 kwh @ 2¢ = $ 0.137/sf/yr

---

Summer ~~Ventilation or~~ Air Conditioning (Term C only):

Equipment: 117 Tons Refrigeration 4-30 Ton Package Units

Installation Cost: $ 76,000 ÷ 15,000 sq. ft. = $ 5.06 per sq. ft.

Operating Cost: $\frac{117T \times 1.4 \times 10 \text{ hrs.} \times 90 \text{ da.} \times \$0.02}{15{,}000 \text{ sq.ft.}}$ = $ 0.196 per sq. ft. per year

---

Assumed Maintenance Costs: None

SUMMARY OF COSTS

STRUCTURE No. 1b

STRUCTURE

Type: Air Supported (Air Conditioned during summers)

Area: 15,000 square feet

Materials:

Roof: Vinyl-coated Nylon Fabric

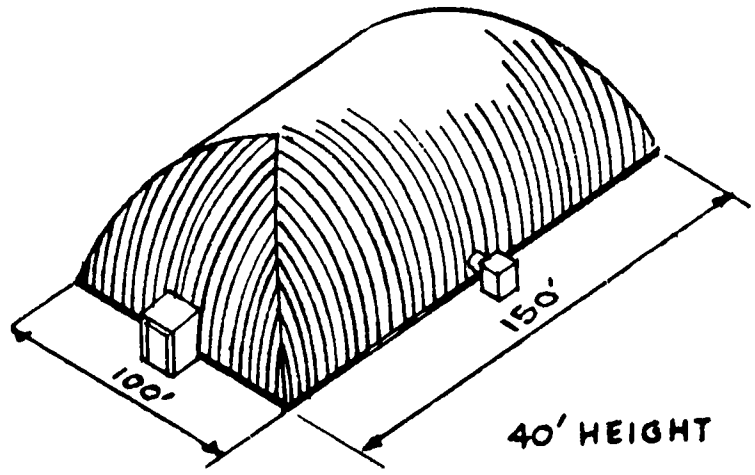
Side walls: " " "

End walls: " " "

Skylights: None

Foundations: Ground Anchors

Estimated Life: 5 years



INITIAL COSTS PER SQUARE FOOT

Building shell*	$ 1.90
Heating & Lighting Eqpmt.	$ 1.60
Total for Terms A & B	$ 3.50
Ventilating Eqpmt.	$ —
Air Conditioning Eqpmt.	$ 5.06
Total for Term C	$ 8.56

U-VALUES (Winter)

Roof	1.20
Skylights	—
Side walls, opaque	—
Side walls, transl.	1.20
End walls, opaque	—
End walls, transl.	1.20

*see Appendix B

BTU LOSS (Winter)

Total: 2,181,020 Btu/hr

Per sq. ft. 145 Btu/hr

SUMMER ~~VENTILATION~~/COOLING

Air Conditioning by 4 package units

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp. +3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period (2 struct.)			20-Year Period (4 struct.)		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over ~~period~~ 5 yrs.	$ 4.27	$ 4.27	$ 10.42	$ 6.71[1]	$ 6.71	$ 14.12	$ 13.10[2]	$ 13.10	$ 27.62
Operating: heat & light	1.18	1.85	1.96	2.36	3.70	3.92	4.72	7.40	7.84
~~ventilating or~~ air cond.	—	—	0.98	—	—	1.96	—	—	3.92
Maintenance	—	—	—	—	—	—	—	—	—
Gross Total Term Costs	5.45	6.12	13.36	9.07	10.41	20.00	17.82	20.50	39.38
Less est. salvage value	0.40	0.40	1.67	0.32	0.32	1.33	—	—	—
NET TOTAL TERM COSTS	$ 5.05	$ 5.72	$ 11.69	$ 8.75	$ 10.09	$ 18.67	$ 17.82	$ 20.50	$ 39.38

1) Credit 10% of shell cost, 80% of mech'l. eqpmt. cost of 1st struct. on cost of 2nd. Net cost of 2nd = $2.03; 3.04 w/ air cond.

2) " " " " " , 60% " " " " " 2nd " " " " 3rd. Net cost of 3rd = $2.35; 4.37 " "
" " " " " , 25% " " " " " 3rd " " " " 4th. Net cost of 4th = $2.91; 6.71 " "

ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	0 %	0 %	0 %
Mechanical equipment:	25 % (of orig. equipmt.)	20 % (orig. equipmt.)	0 %

CALCULATIONS

STRUCTURE No. 1c

Areas:

See Structures No. 1A and 1B

Surface area = approx. 20,850 sq. ft.

Heating: Btu Loss - 20,850 sf x 1.20 = 25,020

_____ x ____ = _____

_____ x ____ = _____

_____ x ____ = _____

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

				Term A	Terms B & C
ventilating air (1 cfm/sf)	15,000	x 1.08	= 16,200		
			41,220 x 60 =	2,473,200	
			+ 10% safety	247,320	
			Gross Btu Loss per hour	2,720,520	2,720,520
Deduct: Heat gain from lighting: 15,000 sf x 3 x 3.4 x 2/9				34,000 (x 1/2 :	76,200
Estimated solar heat gain: 25 % of gross loss				680,130 (17 %:	463,000
			DESIGN BTU LOSS	2,006,390	2,181,020

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 2006.4}{15{,}000 \text{ s.f.}}$ = $ 0.213 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 2181.0}{15{,}000 \text{ s.f.}}$ = $ 0.254 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 2 hr/da x 5 da/wk x 39 wks = 390 hrs x 3w/sf = 1.17 kwh @ 2¢ = $ 0.023/sf/yr

Term B: 7 hr/da x 7 da/wk x 39 wks = 1911 hrs x 3w/sf = 5.73 kwh @ 2¢ = $ 0.115/sf/yr

Term C: 1911 + 4 hrs x 7 x 13 wks = 2275 hrs x 3w/sf = 6.83 kwh @ 2¢ = $ 0.137/sf/yr

---

Summer Ventilation or Air Conditioning (Term C only):

Equipment: None

Installation Cost: $ ____ ÷ ____ sq. ft. = $ 0 per sq. ft.

Operating Cost: $\frac{\text{HP} \times 0.74565 \times \$0.02 \times \quad \text{hrs.}}{\quad \text{sq.ft.}}$ = $ 0 per sq. ft. per year

---

Assumed Maintenance Costs: *Annual dismantling and re-erection of structure - $2000*

5-yr. term - 4 erect., 5 dism. = $9000. 10-yr. term - 8 erect., 10 dism. = $18,000

20 yr. term - 17 erect'ns, 20 dismantlings = $37,000.

SUMMARY OF COSTS

STRUCTURE No. 1C

STRUCTURE

Type: Air Supported (Dismantled & Stored during summers)

Area: 15,000 square feet

Materials:

Roof Vinyl-coated Nylon Fabric

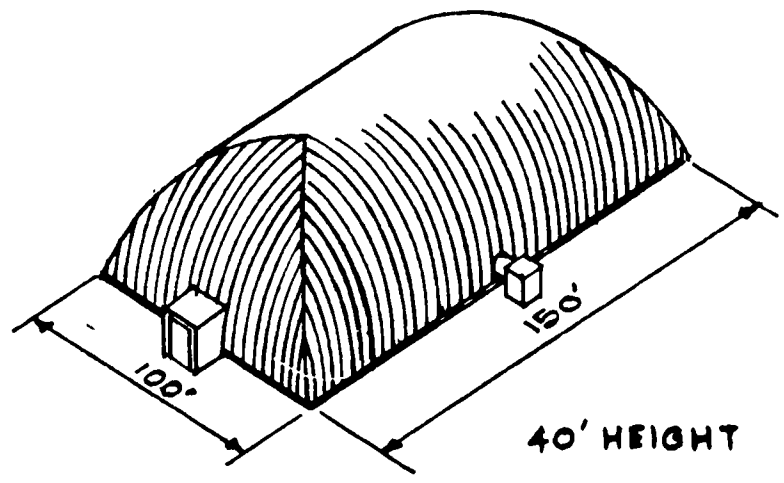
Side walls " " "

End walls " " "

Skylights None

Foundations Ground Anchors

Estimated Life: 7 years



INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 1.97	Roof	1.20	Total: 2,181,200 Btu/hr
Heating & Lighting Eqpmt.	$ 1.60	Skylights	—	Per sq. ft. 145 Btu/hr
Total for Terms A & B	$ 3.57	Side walls, opaque	—	
Ventilating Eqpmt.	$ ____	Side walls, transl.	1.20	SUMMER VENTILATION/COOLING
Air Conditioning Eqpmt.	$ ____	End walls, opaque	—	None - Structure removed
Total for Term C	$ 3.57	End walls, transl.	1.20	
		*see Appendix B		

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C:12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period (2 struct's)			20-Year Period (3 struct's)		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period or 7-yr. life	$ 4.33	$ 4.33	$ 4.33	$ 7.00 (1)	$ 7.00	$ 7.00	$ 10.31 (2)	$ 10.31	$ 10.31
Operating: heat & light	1.18	1.85	1.96	2.36	3.70	3.92	4.72	7.40	7.84
ventilating or air cond.	—	—	—	—	—	—	—	—	—
Maintenance	—	—	0.60	—	—	1.20	—	—	2.46
Gross Total Term Costs	5.51	6.18	6.89	9.36	10.70	12.12	15.03	17.71	20.61
Less est. salvage value	0.80	0.80	0.80	1.15	1.15	1.15	0.12	0.12	0.12
NET TOTAL TERM COSTS	$ 4.71	$ 5.38	$ 6.09	$ 8.21	$ 9.55	$ 10.97	$ 14.91	$ 17.59	$ 20.49

1) 1st struct. amort. over 7 yrs., 2nd over 3 yrs. Net cost of 2nd struct. = $2.08/sq.ft.

2) " " " " ", 2nd " 7 yrs., 3rd over 6 yrs. Net cost of 3rd struct. = $2.40/sq.ft.

For method of estimating net costs of 2nd & 3rd structures, see corresponding notes, Structures 1A & 1B.

ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	20 % (1st. Struct.)	40 % (2nd Struct.)	5 % (3rd Struct.)
Mechanical equipment:	25 % (orig. eqpmt.)	20 % (orig. eqpmt.)	0 %

CALCULATIONS

STRUCTURE No. 1d

Areas:

See Structures No. 1A and 1B

Surface area = approx. 20,850 sq. ft.

Heating: Btu Loss - 20,850sf x 1.20 = 25,020

_____ x ____ = _____

_____ x ____ = _____

_____ x ____ = _____

ventilating air (1 cfm/sf) 15,000 x 1.08 = 16,200

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
41,220 x 60 =	2,473,200	
+ 10% safety	247,320	
Gross Btu Loss per hour	2,720,520	2,720,520
Deduct: Heat gain from lighting: 15,000 sf x 3 x 3.4 x 2/4	34,000 (x 1/2 :	76,200
Estimated solar heat gain: 25 % of gross loss	680,130 (17 %:	463,000
DESIGN BTU LOSS	2,006,390	2,181,020

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 2006.4}{15{,}000 \text{ s.f.}}$ = $ 0.213 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 2181.0}{15{,}000 \text{ s.f.}}$ = $ 0.254 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 2 hr/da x 5 da/wk x 39 wks = 390 hrs x 3w/sf = 1.17 kwh @ 2¢ = $ 0.023/sf/yr

Term B: 7 hr/da x 7 da/wk x 39 wks = 1911 hrs x 3w/sf = 5.73 kwh @ 2¢ = $ 0.115/sf/yr

Term C: 1911 + 4 hrs x 7 x 13 wks = 2275 hrs x 3w/sf = 6.83 kwh @ 2¢ = $ 0.137/sf/yr

---

Summer ~~Ventilation or~~ Air Conditioning (Term C only):

Equipment: 117 Tons Refrigeration 4-30-Ton Package Units

Installation Cost: $ 76,000 ÷ 15,000 sq. ft. = $ 5.06 per sq. ft.

Operating Cost: $\frac{117T \times 1.4 \times 10 \text{ hrs.} \times 90 \text{ da.} \times \$0.02}{15{,}000 \text{ sq.ft.}}$ = $ 0.196 per sq. ft. per year

---

Assumed Maintenance Costs: None

SUMMARY OF COSTS

STRUCTURE No. 1d

STRUCTURE

Type: Air Supported (Air Conditioned during Summers)

Area: 15,000 square feet

Materials:

Roof Vinyl-coated Nylon Fabric

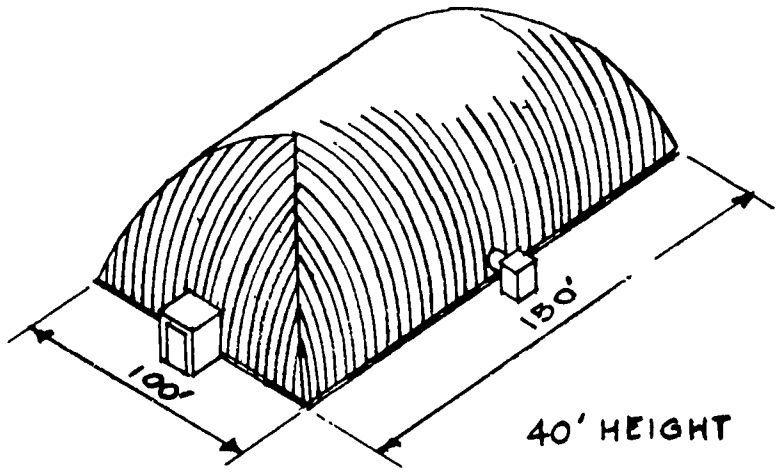
Side walls " " "

End walls " " "

Skylights None

Foundations Ground Anchors

Estimated Life: 7 years



INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 1.97	Roof	1.20	Total: 2,181,020 Btu/hr
Heating & Lighting Eqpmt.	$ 1.60	Skylights	—	Per sq. ft. 145 Btu/hr
Total for Terms A & B	$ 3.57	Side walls, opaque	—	
Ventilating Eqpmt.	$ —	Side walls, transl.	1.20	SUMMER ~~VENTILATION~~/COOLING
Air Conditioning Eqpmt.	$ 5.06	End walls, opaque	—	Air Conditioning by 4 package units
Total for Term C	$ 8.63	End walls, transl.	1.20	
		*see Appendix B		

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period (2 struct's.)			20-Year Period (3 struct's)		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period or 7-yr. life	$ 4.33	$ 4.33	$ 10.52	$ 7.00 (1)	$ 7.00	$ 14.74	$ 10.31 (2)	$ 10.31	$ 20.78
Operating: heat & light	1.18	1.85	1.96	2.36	3.70	3.92	4.72	7.40	7.84
~~ventilating or~~ air cond.	—	—	0.98	—	—	1.96	—	—	3.92
Maintenance	—	—	—	—	—	—	—	—	—
Gross Total Term Costs	5.51	6.18	13.46	9.36	10.70	20.62	15.03	17.71	32.54
Less est. salvage value	0.80	0.80	2.06	1.15	1.15	2.56	0.12	0.12	0.22
NET TOTAL TERM COSTS	$ 4.71	$ 5.38	$ 11.40	$ 8.21	$ 9.55	$ 18.06	$ 14.91	$ 17.59	$ 32.32

1) 1st. Struct. amort. over 7yrs., 2nd over 3yrs. Net cost of 2nd. Struct. = $2.08/sq.ft; $3.10 w/ air cond.

2) " " " " ", 2nd " 7yrs., 3rd over 6yrs. Net cost of 3rd struct. = $2.40/sf, $4.42 w/a.c.

For method of estimating net costs of 2nd & 3rd structures, see corresponding notes, Structures 1A & 1B.

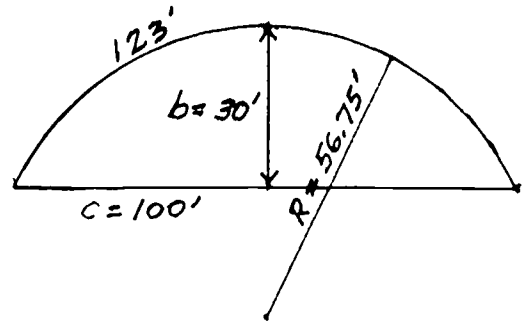
ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	20 % (1st. Struct.)	40 % (2nd Struct.)	5 % (3rd Struct.)
Mechanical equipment:	25 % (orig. eqpmt.)	20 % (orig. eqpmt.)	0 %

CALCULATIONS

STRUCTURE No. 2a

Areas:



Rad. = $\frac{4 \times 30^2 + 100^2}{8 \times 30}$ = 56.75'

b/c = .30; A° = 124

Arc = .017543 x 56.75 x 124 = 123'

Roof area = 150 x 123 x 1.31 = 24,110 sq. ft.

End wall area = 30 x 100 x 0.7125 = 2140 sf.
x 2
4280 sq. ft.

Painting area = say 25,000 sq. ft.

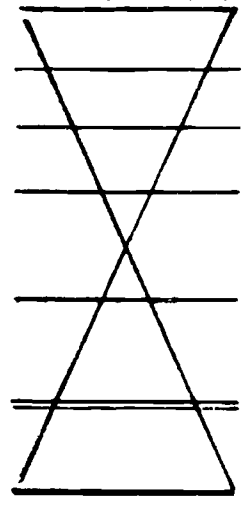
Volume: 2140 x 150 = 321,000 cu. ft.

Heating: Btu Loss –

24,110 sf	x	1.28	=	30,850
4,280	x	1.09	=	4,660
	x		=	
	x		=	
ventilating air (1 cfm/sf) 15,000	x	1.08	=	16,200

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
51,710 x 60 =	3,100,000	
+ 10% safety	310,000	
Gross Btu Loss per hour	3,410,000	
Deduct: Heat gain from lighting: 15,000 sf x 3 x 3.4 x 1.0	153,000 (x ___ :	
Estimated solar heat gain: — % of gross loss	— (___ %:	
DESIGN BTU LOSS	3,257,000	



Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 3257}{s.f.}$ = $ 0.344 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 3257}{s.f.}$ = $ 0.379 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 9 hr/da x 5 da/wk x 39 wks = 1755 hrs x 3w/sf = 5.27 kwh @ 2¢ = $ 0.105/sf/yr
Term B: 14 hr/da x 7 da/wk x 39 wks = 3822 hrs x 3w/sf = 11.47 kwh @ 2¢ = $ 0.23 /sf/yr
Term C: 3822 + 14 hrs x 7 x 13 wks = 5096 hrs x 3w/sf = 15.29 kwh @ 2¢ = $ 0.306/sf/yr

---

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: 4 - 7.5 HP Fans @ 35,000 cfm each

Installation Cost: $ 2200 ÷ 15,000 sq. ft. = $ 0.147 per sq. ft.

Operating Cost: $\frac{30 \text{ HP} \times 0.74565 \times \$0.02 \times 1250 \text{ hrs.}}{15,000 \text{ sq.ft.}}$ = $ 0.038 per sq. ft. per year

---

Assumed Maintenance Costs: Exterior painting 1 coat in 11th, 15th & 18th years @ 6¢ per surface sq.ft. per coat

SUMMARY OF COSTS

STRUCTURE No. 2a

STRUCTURE

Type: Frameless Corrugated Steel Arch ("Wonder")

Area: 15,000 square feet

Materials:

Roof: Steel Sheet, Heavy Corrugations - Painted

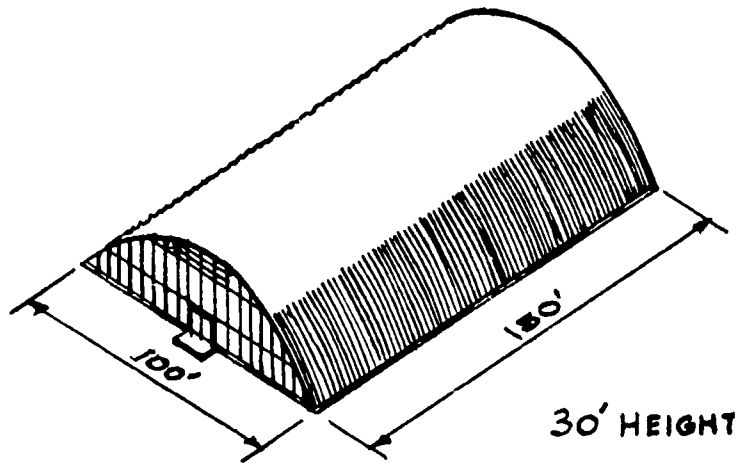
Side walls: same

End walls: Fiberglass-reinforced Plastic removable to 8' height

Skylights: None

Foundations: Concrete - low curb

Estimated Life: 25 years



INITIAL COSTS PER SQUARE FOOT

Building shell*	$ 3.74
Heating & Lighting Eqpmt.	$ 4.36
Total for Terms A & B	$ 8.10
Ventilating Eqpmt.	$ 0.15
Air Conditioning Eqpmt.	$ —
Total for Term C	$ 8.25

U-VALUES (Winter)

Roof	1.28
Skylights	—
Side walls, opaque	1.28
Side walls, transl.	—
End walls, opaque	—
End walls, transl.	1.09

*see Appendix B

BTU LOSS (Winter)

Total: 3,257,000 Btu/hr

Per sq. ft. 217 Btu/hr

SUMMER VENTILATION/~~COOLING~~

Ventilating fans providing 26 air changes per hour

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 9.83	$ 9.83	$ 10.05	$ 11.53	$ 11.53	$ 11.75	$ 15.27	$ 15.27	$ 15.55
Operating: heat & light	2.25	3.05	3.43	4.50	6.10	6.86	9.00	12.20	13.72
ventilating ~~or air cond.~~	—	—	0.19	—	—	0.38	—	—	0.76
Maintenance	—	—	—	—	—	—	0.30	0.30	0.30
Gross Total Term Costs	12.08	12.88	13.67	16.03	17.63	18.99	24.57	27.77	30.33
Less est. salvage value	2.73	2.73	2.77	2.18	2.18	2.21	0.37	0.37	0.37
NET TOTAL TERM COSTS	$ 9.35	$ 10.15	$ 10.90	$ 13.85	$ 15.45	$ 16.78	$ 24.20	$ 27.40	$ 29.96

ESTIMATED SALVAGE VALUES

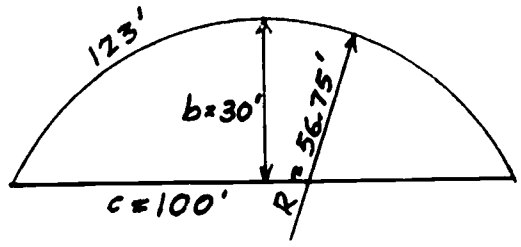
	After 5 Years	After 10 Years	After 20 Years
Building shell:	45 %	35 %	10 %
Mechanical equipment:	25 %	20 %	0 %

All

CALCULATIONS

STRUCTURE No. 2b

Areas:



$Rad. = \frac{4 \times 30^2 + 100^2}{8 \times 30} = 56.75'$

b/c = .30 $A^\circ = 124$

Arc = .017543 x 56.75 x 124 = 123'

Roof Area = 150 x 123 x 1.31 = 24,110 sq.ft.

End wall area = 30 x 100 x 0.7125 = 2140 sq.ft.
x 2
4180 sq.ft.

Painting area = say 25,000 sq.ft.

Volume: 2140 x 150 = 321,000 cu.ft.

Heating: Btu Loss – 24,110 sf x 0.16 = 3,860
4,280 x 1.09 = 4,660
____ x ____ = ____
____ x ____ = ____
ventilating air (1 cfm/sf) 15,000 x 1.08 = 16,200

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
	24,720 x 60 = 1,482,000	
+ 10% safety	148,200	
Gross Btu Loss per hour	1,630,200	
Deduct: Heat gain from lighting: 15,000 sf x 3 x 3.4 x 1.0	153,000 (x ____:	
Estimated solar heat gain: — % of gross loss	— (____%:	
DESIGN BTU LOSS	1,477,200	

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 1477.2}{15,000 \text{ s.f.}}$ = $ 0.156 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 1477.2}{15,000 \text{ s.f.}}$ = $ 0.172 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 9 hr/da x 5 da/wk x 39 wks = 1755 hrs x 3w/sf = 5.27 kwh @ 2¢ = $ 0.105 /sf/yr
Term B: 14 hr/da x 7 da/wk x 39 wks = 3822 hrs x 3w/sf = 11.47 kwh @ 2¢ = $ 0.23 /sf/yr
Term C: 3822 + 14 hrs x 7 x 13 wks = 5096 hrs x 3w/sf = 15.29 kwh @ 2¢ = $ 0.306 /sf/yr

---

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: 4 - 7.5 HP Fans @ 35,000 cfm each

Installation Cost: $ 2200 ÷ 15,000 sq. ft. = $ 0.147 per sq. ft.

Operating Cost: $\frac{30 \text{ HP} \times 0.74565 \times \$0.02 \times 1100 \text{ hrs.}}{15,000 \text{ sq.ft.}}$ = $ 0.033 per sq. ft. per year

---

Assumed Maintenance Costs: Exterior painting 1 coat in 11th, 15th & 18th years @ 6¢ per surface sq.ft. per coat.

SUMMARY OF COSTS

STRUCTURE No. 2b

STRUCTURE

Type: Frameless Corrugated Steel Arch ("Wonder")

Area: 15,000 square feet

Materials:

Roof Steel Sheet, Hvy, Corr., Insulated, Painted

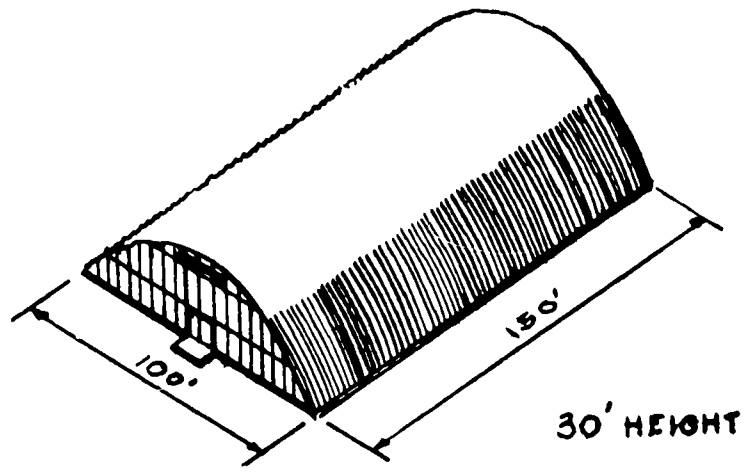
Side walls same

End walls Fiberglass-reinforced Plastic (fixed)

Skylights none

Foundations Concrete - low curb

Estimated Life: 25 years



INITIAL COSTS PER SQUARE FOOT

Building shell*	$ 3.71
Heating & Lighting Eqpmt.	$ 3.49
Total for Terms A & B	$ 7.20
Ventilating Eqpmt.	$ 0.15
Air Conditioning Eqpmt.	$ —
Total for Term C	$ 7.35

U-VALUES (Winter)

Roof	0.16
Skylights	—
Side walls, opaque	0.16
Side walls, transl.	—
End walls, opaque	—
End walls, transl.	1.09

*see Appendix B

BTU LOSS (Winter)

Total: 1,477,200 Btu/hr

Per sq. ft. 98.5 Btu/hr

SUMMER VENTILATION/~~COOLING~~

Ventilating fans providing 26 air changes per hour

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 8.78	$ 8.78	$ 8.97	$ 10.25	$ 10.25	$ 10.47	$ 13.60	$ 13.60	$ 13.88
Operating: heat & light	1.31	2.01	2.39	2.62	4.02	4.78	5.24	8.04	9.56
ventilating ~~or air cond.~~	—	—	0.17	—	—	0.33	—	—	0.66
Maintenance	—	—	—	—	—	—	0.30	0.30	0.30
Gross Total Term Costs	10.09	10.79	11.53	12.87	14.27	15.58	19.14	21.94	24.40
Less est. salvage value	2.33	2.33	2.39	1.81	1.81	1.84	0.37	0.37	0.37
NET TOTAL TERM COSTS	$ 7.76	$ 8.46	$ 9.14	$ 11.06	$ 12.46	$ 13.74	$ 18.77	$ 21.57	$ 24.03

ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	40 %	30 %	10 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 2c

See Structures No. 2 and 2a

Areas:

Skylight area = 66 x 2 x 8 x 1.31 = 1,385 sq. ft.

Insulated roof-wall area = 24,110 - 1,385 = 22,725 sq. ft.

End walls area = 4,280 sq. ft.

Painting area = say 23,600 sq. ft.

Volume: *321,000 cu. ft.*

Heating: Btu Loss –

22,725 sf	x	*0.16*	=	*3,640*	NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.
1,385	x	*1.09*	=	*1,510*	
4,280	x	*1.09*	=	*4,670*	
	x		=		
15,000	x	*1.08*	=	*16,200*	

	Term A	Terms B & C
ventilating air (1 cfm/sf)		
26,020 x 60 =	*1,561,200*	
+ 10% safety	*156,120*	
Gross Btu Loss per hour	*1,717,320*	*1,717,320*
Deduct: Heat gain from lighting: *15,000* sf x 3 x 3.4 x *0.5*	*76,500* (x *0.68*:	*91,800*
Estimated solar heat gain: *4* % of gross loss	*68,700* (*2.8* %:	*48,200*
DESIGN BTU LOSS	*1,572,120*	*1,577,320*

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 1,572.1}{15,000 s.f.}$ = $ *0.166* per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 1,577.3}{15,000 s.f.}$ = $ *0.184* per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: *4½* hr/da x 5 da/wk x 39 wks = *878* hrs x 3w/sf = *2,634* kwh @ 2¢ = $ *0.053*/sf/yr

Term B: *9½* hr/da x 7 da/wk x 39 wks = *2594* hrs x 3w/sf = *7,782* kwh @ 2¢ = $ *0.156*/sf/yr

Term C: *2594* + *6* hrs x 7 x 13 wks = *3140* hrs x 3w/sf = *9,420* kwh @ 2¢ = $ *0.188*/sf/yr

---

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: *4 - 7.5 HP Fans @ 35,000 cfm each*

Installation Cost: $ *2200* ÷ *15,000* sq. ft. = $ *0.147* per sq. ft.

Operating Cost: $\frac{30 \text{ HP} \times 0.74565 \times \$0.02 \times 1200 \text{ hrs.}}{15,000 \text{ sq.ft.}}$ = $ *0.036* per sq. ft. per year

---

Assumed Maintenance Costs: *Exterior painting 1 coat in 11th, 15th and 18th years @ 6¢ per surface sq.ft per coat.*

STRUCTURE

STRUCTURE No. 2C

Type: Frameless Corrugated Steel Arch ("Wonder")

Area: 15,000 square feet

Materials:

Roof Steel Sheet, Hvy. Corr., Insulated, Painted

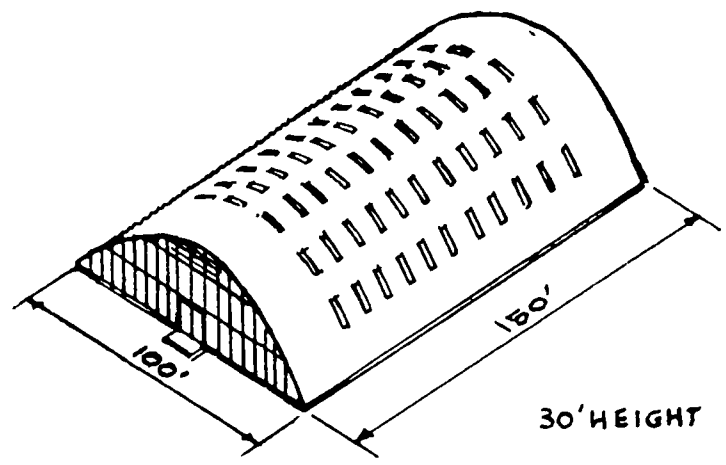
Side walls same

End walls Fiberglass-reinforced Plastic (fixed)

Skylights Fiberglass-reinforced Plastic

Foundations Concrete - low curb

Estimated Life: 25 years



INITIAL COSTS PER SQUARE FOOT

Building shell*	$ 3.92
Heating & Lighting Eqpmt.	$ 3.56
Total for Terms A & B	$ 7.48
Ventilating Eqpmt.	$ 0.15
Air Conditioning Eqpmt.	$ —
Total for Term C	$ 7.63

U-VALUES (Winter)

Roof	0.16
Skylights	1.09
Side walls, opaque	0.16
Side walls, transl.	—
End walls, opaque	—
End walls, transl.	1.09

*see Appendix B

BTU LOSS (Winter)

Total: 1,577,320 Btu/hr

Per sq. ft. 105 Btu/hr

SUMMER VENTILATION/~~COOLING~~

Ventilating fans providing 26 air changes per hour

PERIOD COSTS PER SQUARE FOOT * COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 9.11	$ 9.11	$ 9.30	$ 10.65	$ 10.65	$ 10.86	$ 14.12	$ 14.12	$ 14.40
Operating: heat & light	1.10	1.70	1.86	2.20	3.40	3.72	4.40	6.80	7.44
ventilating ~~or air cond.~~	—	—	0.18	—	—	0.18	—	—	0.18
Maintenance	—	—	—	—	—	—	0.29	0.29	0.29
Gross Total Term Costs	10.21	10.81	11.34	12.85	14.05	14.76	18.81	21.21	22.31
Less est. salvage value	2.26	2.26	2.30	1.69	1.69	1.72	0.39	0.39	0.39
NET TOTAL TERM COSTS	$ 7.95	$ 8.55	$ 9.04	$ 11.16	$ 12.36	$ 13.04	$ 18.42	$ 20.82	$ 21.92

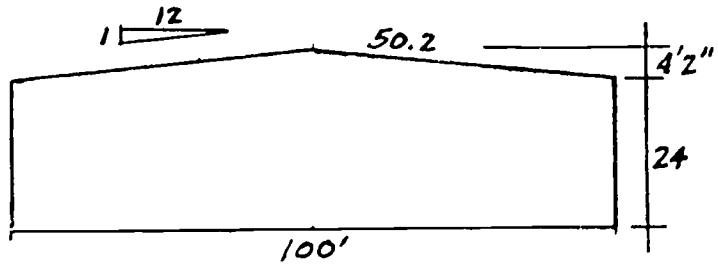
ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	35 %	25 %	10 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 3

Areas:



Roof area = 2 x 50.2 x 144 = 14,458 sq. ft.

Side walls area = 2 x 24 x 144 = 6,912 sq. ft.

End walls area = 2 x 26.08 x 100 x 46/36 = 6,670 s.f.

Painting area = (14,458 + 6912) 46/36 + 400(±)
= 27,700 sq.ft.

Volume: 100 x 144 x 26.08 = 375,550 cu. ft.

Heating: Btu Loss - 14,458 sf x 0.21 = 3,040
6,912 x 0.21 = 1,450
6,670 x 1.09 = 7,270
x =
ventilating air (1 cfm/sf) 14,400 x 1.08 = 15,560

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
27,320 x 60 =	1,639,200	
+ 10% safety	163,920	
Gross Btu Loss per hour	1,803,120	
Deduct: Heat gain from lighting: 14,400 sf x 3 x 3.4 x 1.0	146,880 (x ___ :	
Estimated solar heat gain: — % of gross loss	— (___ %:	
DESIGN BTU LOSS	1,656,240	

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 1656.24}{14,400 \text{ s.f.}}$ = $ 0.183 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 1656.24}{14,400 \text{ s.f.}}$ = $ 0.201 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 9 hr/da x 5 da/wk x 39 wks = 1755 hrs x 3w/sf = 5.27 kwh @ 2¢ = $ 0.105/sf/yr
Term B: 14 hr/da x 7 da/wk x 39 wks = 3822 hrs x 3w/sf = 11.47 kwh @ 2¢ = $ 0.23 /sf/yr
Term C: 3822 + 14 hrs x 7 x 13 wks = 5096 hrs x 3w/sf = 15.29 kwh @ 2¢ = $ 0.306/sf/yr

---

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: 4 - 7.5 HP Fans @ 35,000 cfm each

Installation Cost: $ 2200 ÷ 14,400 sq. ft. = $ 0.153 per sq. ft.

Operating Cost: $\frac{30 \text{ HP} \times 0.74565 \times \$0.02 \times 1260 \text{ hrs.}}{14,400 \text{ sq.ft.}}$ = $ 0.039 per sq. ft. per year

---

Assumed Maintenance Costs: Exterior painting 3 coats between 10th and 20th years @ 6¢ per surf. sq. ft. per coat.

SUMMARY OF COSTS

STRUCTURE No. 3

STRUCTURE

Type: Steel Rigid Frame (Butler)

Area: 14,400 square feet

Materials:

Roof Ribbed Steel Sheets, Painted, Applied Insul.

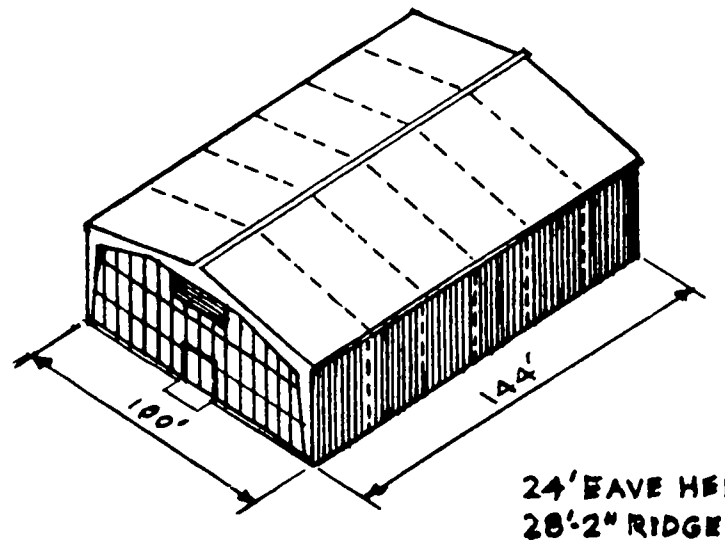
Side walls " " " " " "

End walls Fiberglass-reinforced Plastic

Skylights None

Foundations Concrete

Estimated Life: 25 years



24' EAVE HEIGHT
28'-2" RIDGE HT.

INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 3.80	Roof	0.21	Total: 1,656,240 Btu/hr
Heating & Lighting Eqpmt.	$ 3.70	Skylights	—	Per sq. ft. 115 Btu/hr
Total for Terms A & B	$ 7.50	Side walls, opaque	0.21	
Ventilating Eqpmt.	$ 0.15	Side walls, transl.	—	SUMMER VENTILATION/~~COOLING~~
Air Conditioning Eqpmt.	$ —	End walls, opaque	—	Ventilating fans to provide 22½ air changes per hour
Total for Term C	$ 7.65	End walls, transl.	1.09	
		*see Appendix B		

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp. +3°F max.; off hours, 45°F min. (4200 DD)

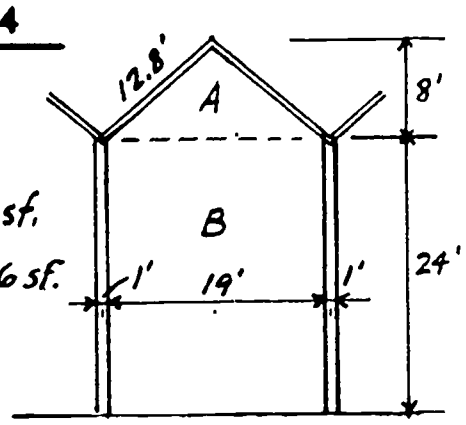
	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 9.14	$ 9.14	$ 9.32	$ 10.68	$ 10.68	$ 10.89	$ 14.15	$ 14.15	$ 14.42
Operating: heat & light	1.44	2.16	2.54	2.88	4.32	5.08	5.76	8.64	10.16
ventilating ~~or air cond.~~	—	—	0.20	—	—	0.39	—	—	0.78
Maintenance	—	—	—	—	—	—	0.33	0.33	0.33
Gross Total Term Costs	10.58	11.30	12.06	13.56	15.00	16.36	20.24	23.12	25.69
Less est. salvage value	2.25	2.25	2.29	1.88	1.88	1.91	0.38	0.38	0.38
NET TOTAL TERM COSTS	$ 8.33	$ 9.05	$ 9.77	$ 11.68	$ 13.12	$ 14.45	$ 19.86	$ 22.74	$ 25.31

ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	35 %	30 %	10 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 4



Areas:

Area A = 76 sf.

Area B = 456 sf.

Roof area = $^{12.8}/_{10}$ x 100 x 140 = 17,920 sq.ft.

Opaque Side wall area = 8 x 532 + 16 x 1 x 24
= 4540 sq. ft.

Opaque End wall area = 4 x 20.5 x 24 + 4 x 1 x 22
+ 2 x 2 x 59 = 2292 sq. ft.

Total opaque wall area = 4540 + 2292 = 6832 s.f.

Translucent wall area = 6 x 532 + 19 x 22
= 5700 sq. ft.

Volume: 100 x 140 x (28 - 0.5) = 385,000 cu.ft.

Painting area = say 7000 sq.ft.

Heating: Btu Loss –

17,920 sf	x	0.10	=	1,792
6,832	x	0.16	=	1,093
5,700	x	1.09	=	6,213
	x		=	
ventilating air (1 cfm/sf) 14,000	x	1.08	=	15,120

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
24,218 x 60 =	1,453,080	
+ 10% safety	145,310	
Gross Btu Loss per hour	1,598,390	1,598,390
Deduct: Heat gain from lighting: 14,000 sf x 3 x 3.4 x 7/9	111,000 (x 1/4:	112,300
Estimated solar heat gain: 8 % of gross loss	127,870 (5%:	79,920
DESIGN BTU LOSS	1,359,520	1,406,170

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 1359.5}{14,000 s.f.}$ = $ 0.154 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 1406.2}{14,000 s.f.}$ = $ 0.176 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 7 hr/da x 5 da/wk x 39 wks = 1365 hrs x 3w/sf = 4,095 kwh @ 2¢ = $ 0.082/sf/yr
Term B: 12 hr/da x 7 da/wk x 39 wks = 3306 hrs x 3w/sf = 9,918 kwh @ 2¢ = $ 0.198/sf/yr
Term C: 3306 + 10 hrs x 7 x 13 wks = 4216 hrs x 3w/sf = 12,648 kwh @ 2¢ = $ 0.253/sf/yr

---

Summer Ventilation or Air Conditioning (Term C only):

Equipment: 4 - 7.5 HP Fans @ 38,000 cfm each

Installation Cost: $ 2200 ÷ 14,000 sq. ft. = $ 0.157 per sq. ft

Operating Cost: $\frac{30 HP \times 0.74565 \times \$0.02 \times 900 hrs.}{14,000 sq.ft.}$ = $ 0.029 per sq. ft. per year

---

Assumed Maintenance Costs: Painting exterior walls 1 coat every 4th year (4th, 8th, 12th & 16th)
@ 6¢ per surf. sq. Ft. per coat.

SUMMARY OF COSTS

STRUCTURE No. 4

STRUCTURE

Type: Plywood - Folded Plate Roof

Area: 14,000 square feet

Materials:

Roof Insulated Plywd. Panels, Roll Roofing

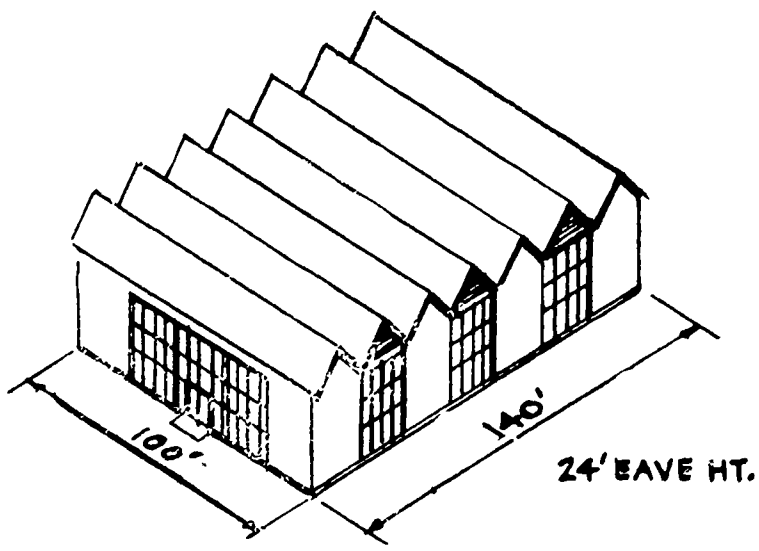
Side walls Insul. Plywd. Panels, FRP Panels

End walls " " " " "

Skylights None

Foundations Concrete

Estimated Life: 25 years



INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 5.32	Roof	0.10	Total: 1,406,170 Btu/hr
Heating & Lighting Eqpmt.	$ 3.56	Skylights	—	Per sq. ft. 100.5 Btu/hr
Total for Terms A & B	$ 8.88	Side walls, opaque	0.16	
Ventilating Eqpmt.	$ 0.16	Side walls, transl.	1.09	SUMMER VENTILATION/~~COOLING~~
Air Conditioning Eqpmt.	$ —	End walls, opaque	0.16	Ventilating fans to provide 24.3 air changes per hour
Total for Term C	$ 9.04	End walls, transl.	1.09	
		*see Appendix B		

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 10.83	$ 10.83	$ 11.04	$ 12.66	$ 12.66	$ 12.87	$ 16.76	$ 16.76	$ 17.05
Operating: heat & light	1.18	1.87	2.15	2.36	3.74	4.30	4.72	7.48	8.60
ventilating ~~or air cond.~~	—	—	0.15	—	—	0.29	—	—	.58
Maintenance	0.03	0.03	0.03	0.06	0.06	0.06	0.12	0.12	0.12
Gross Total Term Costs	12.04	12.73	13.37	15.08	16.46	17.52	21.60	24.36	26.35
Less est. salvage value	3.55	3.55	3.59	2.84	2.84	2.87	0.53	0.53	0.53
NET TOTAL TERM COSTS	$ 8.49	$ 9.18	$ 9.78	$ 12.24	$ 13.62	$ 14.65	$ 21.07	$ 23.83	$ 25.82

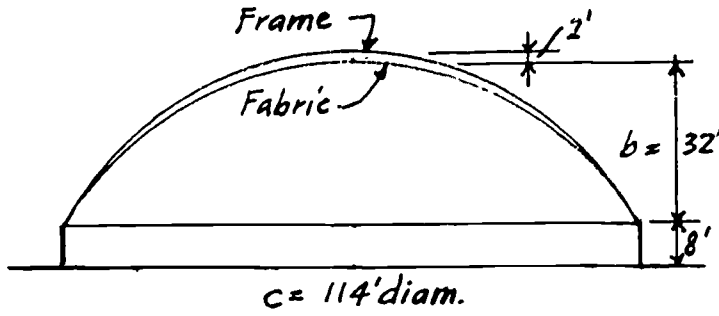
ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	50 %	40 %	10 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 5

Areas:



Wall area = $114 \times \pi \times 8 = 2870$ sq. ft.

Fabric dome surface area

$\cong \frac{\pi(4b^2+c^2)}{4} = \frac{\pi(4\times32^2+114^2)}{4}$

$\cong$ 13,425 sq. ft.

Volume: $\frac{8\pi c^2}{4} + \frac{\pi b(3c^2+4b^2)}{24} = 81,656 + 180,470 = 262,126$ cu. ft.

Heating: Btu Loss –

2,870 sf	x	0.16	=	460
13,425	x	1.2	=	16,110
	x		=	
	x		=	
ventilating air (1 cfm/sf) 10,200	x	1.08	=	11,020

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
27,590 x 60 =	1,655,400	
+ 10% safety	165,540	
Gross Btu Loss per hour	1,820,940	1,820,940
Deduct: Heat gain from lighting: 10,200 sf x 3 x 3.4 x 2/9	23,120 (x 1/2 :	52,020
Estimated solar heat gain: 25 % of gross loss	454,230 (17 %:	310,000
DESIGN BTU LOSS	1,343,590	1,458,920

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 1343.6}{10,200 \text{ s.f.}}$ = $ 0.209 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 1458.9}{10,200 \text{ s.f.}}$ = $ 0.25 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 2 hr/da x 5 da/wk x 39 wks = 390 hrs x 3w/sf = 1.17 kwh @ 2¢ = $ 0.023/sf/yr
Term B: 7 hr/da x 7 da/wk x 39 wks = 1911 hrs x 3w/sf = 5.73 kwh @ 2¢ = $ 0.115/sf/yr
Term C: 1911 + 4 hrs x 7 x 13 wks = 2275 hrs x 3w/sf = 6.83 kwh @ 2¢ = $ 0.137/sf/yr

---

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: 3 - 7.5 HP Fans @ 38,000 cfm each

Installation Cost: $ 1800 ÷ 10,200 sq. ft. = $ 0.177 per sq. ft.

Operating Cost: $\frac{22.5\text{HP} \times 0.74565 \times \$0.02 \times 1275 \text{ hrs.}}{10,200 \text{ sq.ft.}}$ = $ 0.042 per sq. ft. per year

---

Assumed Maintenance Costs: Replacement of fabric dome every 6th year @ $1.45/sf. of covered area. Painting of 8' metal wall 1 coat in 11th, 15th and 18th years @ 6¢/surf. sq.ft. per coat.

SUMMARY OF C.

STRUCTURE No. 5

STRUCTURE

Type: Geodesic Dome (Charter Industries)

Area: 10,200 square feet

Materials:

Roof Alum. Geodesic Frame, Suspended Coated Nylon Fabric

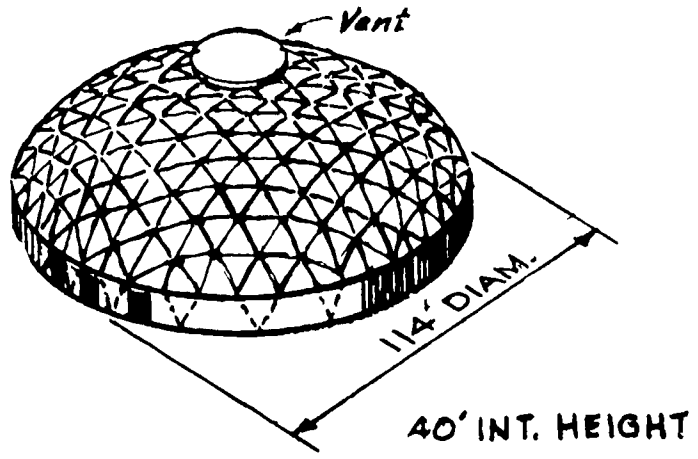
Side walls Insul. Metal Sheets - removable sections

End walls None

Skylights None

Foundations Concrete

Estimated Life: Fabric - 6 years; Frame & walls - 20 years ±



INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 4.94	Roof	1.2	Total: 1,458,920 Btu/hr
Heating & Lighting Eqpmt.	$ 4.18	Skylights	—	Per sq. ft. 143 Btu/hr
Total for Terms A & B	$ 9.12	Side walls, opaque	0.16	
Ventilating Eqpmt.	$ 0.18	Side walls, transl.	—	SUMMER VENTILATION/~~COOLING~~
Air Conditioning Eqpmt.	$ —	End walls, opaque	—	Ventilating fans providing 26 air changes per hour
Total for Term C	$ 9.30	End walls, transl.	—	
		*see Appendix B		

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp. +3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 11.11	$ 11.11	$ 11.33	$ 13.00	$ 13.00	$ 13.24	$ 17.21	$ 17.21	$ 17.55
Operating: heat & light	1.16	1.83	1.94	2.32	3.66	3.88	4.64	7.32	7.76
ventilating ~~or air cond.~~	—	—	0.21	—	—	0.42	—	—	0.84
Maintenance	—	—	—	1.45	1.45	1.45	4.40	4.40	4.40
Gross Total Term Costs	12.27	12.94	13.48	16.77	18.11	18.99	26.25	28.93	30.55
Less est. salvage value	2.78	2.78	2.83	2.31	2.31	2.35	0.49	0.49	0.49
NET TOTAL TERM COSTS	$ 9.49	$ 10.16	$ 10.65	$ 14.46	$ 15.80	$ 16.64	$ 25.76	$ 28.44	$ 30.06

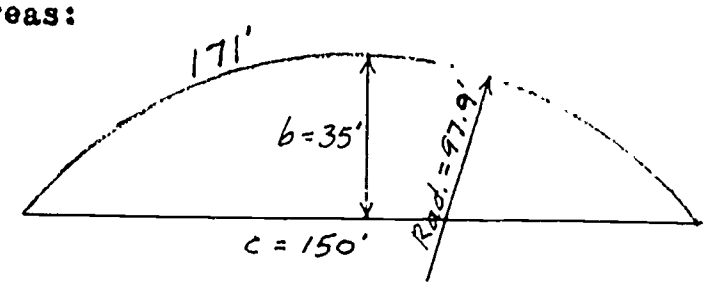
ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	35 %	30 %	10 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 6

Areas:



Volume: 3,650 x 200 = 730,000 cu. ft.

$Radius = \frac{4 \times 35^2 + 150^2}{8 \times 35} = 97.9'$

$b/c = \frac{35}{150} = .2335 \quad A^\circ = 100$

$Arc = 0.017453 \times 97.9 \times 100 = 171'$

Roof area (insul.) = 200 x 171 = 34,200 sf.
Cross Sect'n area = 0.695 x 35 x 150 = 3,650 sf.
End Wall areas = 3,650 x 46/36 x 2 = 9,330 sf.
Painting area = 34,200 x 46/36 + 1200(±)
= say 45,000 sf.

Heating: Btu Loss –

34,200 sf	x	0.16	=	5,470
9,330	x	1.09	=	10,170
	x		=	
	x		=	
ventilating air (1 cfm/sf) 30,000	x	1.08	=	32,400

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar Heat gain.

	Term A	Terms B & C
48,040 x 60 =	2,882,400	
+ 10% safe	288,240	
Gross Btu Loss per hour	3,170,640	
Deduct: Heat gain from lighting: 30,000 sf x 3 x 3.4 x 1.0	306,000 (x ___ :	
Estimated solar heat gain: ___ % of gross loss	___ (___%:	
DESIGN BTU LOSS	2,864,640	

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 2,864.6}{30,000 s.f.}$ = $ 0.152 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 2,864.6}{30,000 s.f.}$ = $ 0.167 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

Lighting (3 watts per square foot):

Term A: 9 hr/da x 5 da/wk x 39 wks = 1755 hrs x 3w/sf = 5.27 kwh @ 2¢ = $ 0.105/sf/yr
Term B: 14 hr/da x 7 da/wk x 39 wks = 3822 hrs x 3w/sf = 11.47 kwh @ 2¢ = $ 0.23/sf/yr
Term C: 3822 + 14 hrs x 7 x 13 wks = 5096 hrs x 3w/sf = 15.29 kwh @ 2¢ = $ 0.306/sf/yr

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: 8 - 7.5 HP Fans @ 38,000 cfm each

Installation Cost: $ 4400 ÷ 30,000 sq. ft. = $ 0.147 per sq. ft.

Operating Cost: $\frac{60 HP \times 0.74565 \times \$0.02 \times 1100 hrs.}{30,000 sq.ft.}$ = $ 0.033 per sq. ft. per year

Assumed Maintenance Costs: Painting exterior 3 coats between 10th and 20th years @ 6¢ per surface sq. ft. per coat.

SUMMARY OF COSTS

STRUCTURE No. 6

STRUCTURE

Type: Trussed Steel Arch (Butler "Triodetic")

Area: 30,000 square feet

Materials:

Roof Sheet Steel Ribbed Panels, Painted, Applied Insulation

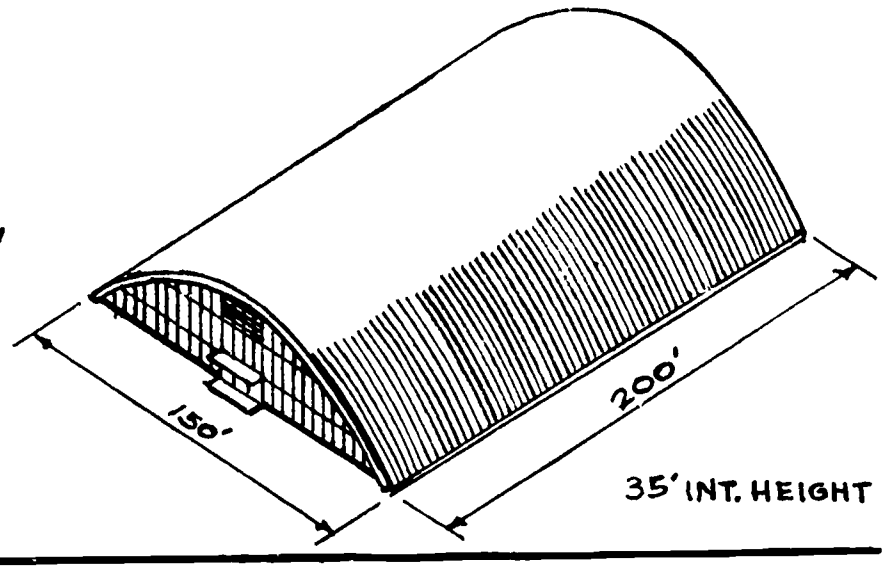
Side walls None

End walls Fiberglass-reinforced Plastic

Skylights None

Foundations Concrete

Estimated Life: 25 years



INITIAL COSTS PER SQUARE FOOT		U-VALUES (Winter)		BTU LOSS (Winter)
Building shell*	$ 3.44	Roof	0.16	Total: 2,864,640 Btu/hr
Heating & Lighting Eqpmt.	$ 3.23	Skylights	—	Per sq. ft. 95.5 Btu/hr
Total for Terms A & B	$ 6.67	Side walls, opaque	—	
Ventilating Eqpmt.	$ 0.15	Side walls, transl.	—	SUMMER VENTILATION/~~COOLING~~
Air Conditioning Eqpmt.	$ —	End walls, opaque	—	Ventilating fans providing 25 air changes per hour
Total for Term C	$ 6.82	End walls, transl.	1.09	
		*see Appendix B		

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp.+3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 8.13	$ 8.13	$ 8.31	$ 9.50	$ 9.50	$ 9.70	$ 12.58	$ 12.58	$ 12.86
Operating: heat & light	1.39	1.99	2.37	2.78	3.98	4.74	5.56	7.96	9.48
ventilating ~~or air cond.~~	—	—	0.17	—	—	0.34	—	—	0.68
Maintenance	—	—	—	—	—	—	0.27	0.27	0.27
Gross Total Term Costs	9.52	10.12	10.85	12.28	13.48	14.78	18.41	20.81	23.29
Less est. salvage value	2.01	2.01	2.05	1.68	1.68	1.71	0.34	0.34	0.34
NET TOTAL TERM COSTS	$ 7.51	$ 8.11	$ 8.80	$ 10.60	$ 11.80	$ 13.07	$ 18.07	$ 20.47	$ 22.95

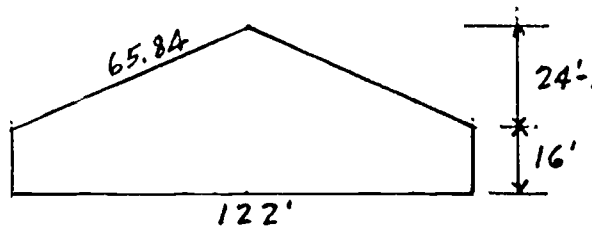
ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	35 %	30 %	10 %
Mechanical equipment:	25 %	20 %	0 %

CALCULATIONS

STRUCTURE No. 7

Areas:



Slope dimension = $\sqrt{61^2 + 24.67^2}$ = 65.84'

Roof area = 2 x 65.84 x 306 = 40,295 sq.ft

Wall area = 2 x 16 x 306 + 2 x 28.33 x 122
= 16,705 sq.ft.

Volume: 120 x 304 x 28.33 = 1,033,600 cu.ft.

Heating: Btu Loss –

40,295 sf	x	0.12	=	4,835
16,705	x	0.38	=	6,350
	x		=	
	x		=	
ventilating air (1 cfm/sf) 37,332	x	1.08	=	40,320

NOTE: Btu loss for Terms B & C differ only in structures having high daylight & solar heat gain.

	Term A	Terms B & C
51,505 x 60 =	3,090,300	
+ 10% safety	309,030	
Gross Btu Loss per hour	3,399,330	
Deduct: Heat gain from lighting: 37,322 sf x 3 x 3.4 x 1.0	380,685 (x ___ :	
Estimated solar heat gain: — % of gross loss	— (___ %:	
DESIGN BTU LOSS	3,018,645	

Fuel Cost (#4 oil @ 10.5¢/gal., 70% efficiency):

Term A: $\frac{141/148 \times 0.00437 \times 3815DD \times 3,018.6}{37,332 \text{ s.f.}}$ = $ 0.128 per sq.ft. per yr.

Terms B & C: $\frac{141/148 \times 0.00437 \times 4200DD \times 3,018.6}{37,332 \text{ s.f.}}$ = $ 0.142 per sq.ft. per yr.

Blower operating cost for winter ventilation assumed to be same for all structures

---

Lighting (3 watts per square foot):

Term A: 9 hr/da x 5 da/wk x 39 wks = 1755 hrs x 3w/sf = 5.27 kwh @ 2¢ = $ 0.105/sf/yr
Term B: 14 hr/da x 7 da/wk x 39 wks = 3822 hrs x 3w/sf = 11.47 kwh @ 2¢ = $ 0.23/sf/yr
Term C: 3822 + 14 hrs x 7 x 13 wks = 5096 hrs x 3w/sf = 15.29 kwh @ 2¢ = $ 0.306/sf/yr

---

Summer Ventilation ~~or Air Conditioning~~ (Term C only):

Equipment: 12 - 7.5HP Fans @ 38,000 cfm each

Installation Cost: $ 7000 ÷ 37,332 sq. ft. = $ 0.187 per sq. ft.

Operating Cost: $\frac{90 \text{ HP} \times 0.74565 \times \$0.02 \times 1100 \text{ hrs.}}{37,332 \text{ sq.ft.}}$ = $ 0.04 per sq. ft. per year

---

Assumed Maintenance Costs: None

SUMMARY OF COSTS

STRUCTURE No. 7

STRUCTURE

Type: Rigid Steel Frame (Varco-Pruden)

Area: 37,332 square feet

Materials:

Roof Ribbed Steel Sheets, Deck Insulation

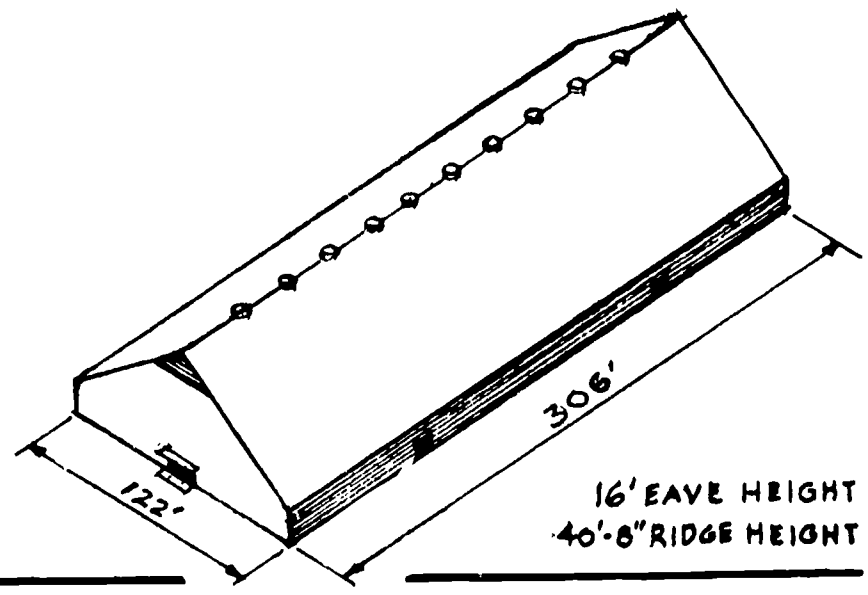
Side walls 12" Lightwt. Conc. Blocks

End walls " " "

Skylights None

Foundations Concrete

Estimated Life: 30 years



16' EAVE HEIGHT
40'-8" RIDGE HEIGHT

INITIAL COSTS PER SQUARE FOOT

Building shell*	$ 2.81
Heating & Lighting Eqpmt.	$ 3.05
Total for Terms A & B	$ 5.86
Ventilating Eqpmt.	$ 0.14
Air Conditioning Eqpmt.	$ —
Total for Term C	$ 6.05

U-VALUES (Winter)

Roof	0.12
Skylights	—
Side walls, opaque	0.35
Side walls, transl.	—
End walls, opaque	0.35
End walls, transl.	—

*see Appendix B

BTU LOSS (Winter)

Total: 3,018,645 Btu/hr

Per sq. ft. 81 Btu/hr

SUMMER VENTILATION/~~COOLING~~

Ventilating fans providing 25 air changes per hour.

PERIOD COSTS PER SQUARE FOOT OF COVERAGE

Term A: 9 mo/yr, 5 days/wk, 8AM -5PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (3815 DD)

Term B: 9 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min. off hours, 45°F min. (4200 DD)

Term C: 12 mo/yr, 7 days/wk, 8AM-10PM. Interior temperatures: during use, 60°F min., outdoor temp. +3°F max.; off hours, 45°F min. (4200 DD)

	5-Year Period			10-Year Period			20-Year Period		
	Term A	Term B	Term C	Term A	Term B	Term C	Term A	Term B	Term C
Bldg. cost amortized at 7% over period	$ 7.14	$ 7.14	$ 7.38	$ 8.35	$ 8.35	$ 8.62	$ 11.07	$ 11.07	$ 11.41
Operating: heat & light	1.17	1.66	2.24	2.34	3.32	4.48	4.68	6.64	8.96
ventilating ~~or air cond.~~	—	—	0.20	—	—	0.40	—	—	0.80
Maintenance	—	—	—	—	—	—	—	—	—
Gross Total Term Costs	8.31	8.80	9.82	10.69	11.67	13.50	15.75	17.71	21.17
Less est. salvage value	1.46	1.46	1.51	1.22	1.22	1.26	0.42	0.42	0.42
NET TOTAL TERM COSTS	$ 6.85	$ 7.34	$ 8.31	$ 9.47	$ 10.45	$ 12.24	$ 15.33	$ 17.29	$ 20.75

ESTIMATED SALVAGE VALUES

	After 5 Years	After 10 Years	After 20 Years
Building shell:	25 %	22 %	15 %
Mechanical equipment:	25 %	20 %	0 %

DERIVATION OF BUILDING SHELL COSTS

Air-supported Structures (Nos. 1a, 1b, 1c, 1d)

Package price listed by Air-Tech Industries for 118'x 156' (18,408 sf) structure		$ 32,650	
Shipping and erection *		1,850	
		$ 34,500	
	34,500/18,408 = 1.87;		say $ 1.90/sq.ft.
Mech'l. equipment:	Listed heater price	$ 11,130	
	Shipping and installation*	3,000	
	Listed cost of lighting	10,000	
	Shipping and installation*	4,250	
		$ 28,380	
	28,380/18,408 = 1.54;		say $ 1.60/sq.ft.

5-year life structure - $ 3.50/sq.ft.

Shell cost of 7-year-life structure assumed to be 7¢/sf higher* ($1.97)

Replacement costs:

Net cost of 2nd structure:	Removal of 1st structure	$ 1000	
	Cost of 2nd shell	28250	(7-yr.-29400)
	Shipping & erection of 2nd	1300	
		30550	say $2.03/sf (5-yr.)
			2.10/sf (7-yr.)

90% of original shell cost = 1.71 (1.76 for 7-yr.)
20% of mechanicals cost = 0.32 (1.33 with a.c.)

5-yr. structure: 1.71 + 0.32 = 2.03 w/out a.c., w/a.c. 1.71 + 1.33 = 3.04
7-yr. structure: 1.76 + 0.32 = 2.08 w/out a.c., w/a.c. 1.76 + 1.33 = 3.10

Net cost of 3rd structure: 90% of original shell cost = 1.71 (1.76 for 7-yr.)
40% of mechanicals cost = 0.64 (2.66 w/a.c.)

5-yr. structure: 1.71 + 0.64 = 2.35 w/out a.c., w/a.c. 1.71 + 2.66 = 4.37
7-yr. structure: 1.76 + 0.64 = 2.40 w/out a.c., w/a.c. 1.76 + 2.66 = 4.42

Net cost of 4th structure (5-year life): 90% of original shell cost = 1.71
75% of mechanicals cost = 1.20 (5.00)
5-yr. structure: 1.71 + 1.20 = 2.91 w/out a.c., w/a.c. 1.71 + 5.00 = 6.71

Wonder Building No. 2a

Package building (metal end walls, no skylights) quoted at	$ 37,500	
Foundation work *	5,300	
Erection *	6,000	
Substitution of plastic end walls with removable sections	5,200	
Exterior painting	2,100	
	$ 56,100	

56,100/ 15,000 = $ 3.74 per sq.ft.

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* All items so starred were estimated by author

Estimated cost of Structure 2a	$ 56,100
Deduct cost of removable end wall sections *	2,000
	54,100
Add cost of insulation @ 6¢ per sq.ft.*(sprayed)	1,450
	$ 55,550

55,550/15,000 = $ 3.71 per sq.ft.

Wonder Building No. 2c

Estimated cost of Structure 2b	$ 55,550
Add cost of skylights, 66 @ $50 each *	3,300
	$ 58,850

58,850/15,000 = $ 3.92 per sq.ft.

Butler Rigid Frame Metal Building No. 3

Price quoted by area representative for 100'x 150' building with insulated roof, 28 skylight panels, all exterior painted, including foundations, erection and 10% mark-up $ 56,160

Deduct cost of skylights	770
	$ 55,390
Add wall insulation *	1,450
	$ 56,840
Estimated reduction for decreasing building length to 144' *	2,120
	$ 54,720

54,720/14,400 = $ 3.80 per sq.ft.

Plywood Building No. 4

Price quoted jointly by Champlin Company of Hartford, component manufacturers, and Treeplex Company, Somerset N.J., structural service, for building completely erected on foundations, including translucent wall areas: $ 73,400

Add for bolted (demountable) connections *	1,100
	$ 74,500

74,500/14,000 = $ 5.32 per sq.ft.

Geodesic Dome Structure No. 5

Price quoted by Charter Industri for building of identical type and size but without side walls: $ 4.51 per sq.ft. of coverage

Add for metal sidewalls with interior applied insulation *	0.43
	$ 4.94 per sq.ft.

Replacement cover quoted at $1.35/sq.ft. of covered area; 10¢ per sq.ft. added for installation cost

Trussed Steel Arch Building No. 6

Price quoted by Butler Mfg. Co. for identical building, completely erected, but only 30 feet in height:

	$ 100,365
Estimated increase for increasing height to 35' *	2,865
	$ 103,230

103,230/30,000 = $ 3.44 per sq.ft.

Varco-Pruden Rigid Frame Building No. 7

Contract prices for similar building erected September 1969 in Somerset County, N.J.:

Foundations	$ 7,000
Steel frame and insulated metal roof	75,000
Block walls @ 1.00 per sq.ft.	17,500
	$ 99,500
Add for doors and entrances *	6,000
	$105,500

105,500/37,322 = $ 2.81 per sq.ft.

SOURCES OF SUPPLY FOR THE STRUCTURES ANALYZED

Air-Supported Structures

are available from several manufacturers, including:

Air-Tech Industries, Inc.
9 Brighton Road, Clifton, N.J. 07012

Birdair Structures, Inc.
1800 Broadway, Buffalo, N.Y. 14212

Cidair Structures Company
130th & Indiana Avenue, Chicago, Ill. 60627

ILC Industries
350 Pear Street, Dover, Delaware 19901

Steel Structures of many different types are available from a large number of manufacturers. The suppliers of the buildings analyzed in this study are:

Wonder Trussless Building, Inc.
2901 South Cicero Avenue, Chicago, Ill. 60650

Butler Manufacturing Company
7400 East 13th Street, Kansas City, Mo. 64026

Varco-Pruden, Inc.
PO Box 6868, Pine Bluff, Arkansas 71601

Plywood Structures

are available from suppliers in all areas of the country. Information as to local sources may be obtained by contacting

American Plywood Association
1119 A Street, Tacoma, Washington 98401

Geodesic Dome Structures of the type analyzed in this study are supplied by

Charter Industries, Inc.
Raleigh, North Carolina

Similar structures are available also from other sources.